The Influence of Statutory Land Use Planning on Water Sensitive Urban Design Practices

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A thesis submitted for the degree of Doctor of Philosophy at
Monash University in 2017
Faculty of Law

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Abstract

This thesis examines how statutory land use planning influences the adoption of water sensitive urban design practices in Australian jurisdictions. Australian governments have included support for water sensitive urban design in the national urban water reform agenda, and have included provisions intended to encourage water sensitive urban design practices in statutory land use planning regimes. However, detailed empirical investigation of the extent to which statutory land use planning actually encourages, or hinders, the adoption of water sensitive urban design practices, and how this occurs, is lacking. This thesis addresses this gap in knowledge.

The thesis examines the water sensitive urban design concept, showing that it is a contested, protean term. A specific definition of water sensitive urban design is adopted and water sensitive urban design practice is resolved into a series of components, which reflect the definition. These components provide a more rigorous framework for the research compared with previous investigations, which considered water sensitive urban design practice as an undifferentiated whole.

This framework is then used in an empirical investigation of how statutory land use planning influences water sensitive urban design practices. This research includes a survey and four case studies. Two of the case studies are located in the state of Victoria and two in the state of Western Australia, allowing the statutory systems in these jurisdictions to be compared.

The thesis found that statutory land use planning is an important factor in the adoption of water sensitive urban design practices. At a simplistic level this is unsurprising, because of the mandatory nature of such planning rules. However, the research also found that statutory tools that include specific, quantitative targets more strongly encourage the adoption of water sensitive urban design practices, compared with tools that lack such targets. More broadly, it was also observed that much commentary favours a water sensitive urban design concept that encompasses the complete urban water cycle, and links this with the urban design process. However, current statutory land use planning regimes do not adequately embody this broader concept, and instead focus on the stormwater element of the urban water cycle.

A comparison of the findings of the Victorian and Western Australian case studies showed that the capacity of statutory land use planning to encourage water sensitive urban design practices is enhanced when statutory planning explicitly encourages the adoption of these measures at the localised, street scale. This encourages the transition, central to the water sensitive urban design idea, from the previous reliance on large-scale urban water systems, to a combination of centralised and decentralised systems.

The thesis also finds that statutory land use planning interprets the water sensitive urban design concept, by encouraging specific practices. These practices, in turn, reinforce our assumptions as what water sensitive urban design might be. This process acts as a barrier to the acceptance of wider visions of water sensitive urban design, incorporating the complete urban water cycle, integrated with land use planning.

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

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Date: 4 September 2017

Acknowledgements

I am absolutely clear about how to commence these acknowledgements. My wife Pamela was my indispensable support from the first to the last, without whose encouragement, tolerance and good humour the work described in this thesis would never have taken place. In fact, without her support, I would not have been bold enough to consider taking on the challenge of doctoral research, after being occupied with a career for a number of years. I recall very clearly discussing with Pamela about whether to take that first, fateful step of contacting the Cooperative Research Centre for Water Sensitive Cities. Fortunately, as usual, she was right.

To my patient, good-humoured supervisors, Professor Graeme Hodge and Dr Colin Campbell, thank you so much. Graeme and Colin provided guidance that was, in equal measure, exacting and encouraging. They showed me the rewards associated with thinking critically about a research problem, being brave enough to strike out into the uncharted void and ultimately to map some very small part of that void. Graeme and Colin were a great supervisory team and I benefited from their contrasting, but complementary contributions. Beyond that, there was a great sense of fun and good humour at our meetings. Scholarly research is a serious enterprise, but it was never too serious with Graeme and Colin.

I am indebted to my late parents, Alan and Isobel. Both were brought up in regional Victoria, in circumstances that meant they completed their formal education in early secondary school. However, they deeply valued education and provided me with unfailing support, while I completed an undergraduate degree and a Masters degree. They would be pleased it didn't end there. Mum and Dad, thank you for instilling my life-long love of learning.

I thank my colleagues at the Cooperative Research Centre for Water Sensitive Cities for their support and encouragement, and critical insights.

I would like to acknowledge the support of the Commonwealth of Australia, through the Cooperative Research Centre Programme.

Finally, when things got tough and I needed a break, I knew I could always rely on my ever-present personal barista.

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List of Abbreviations

Abbreviation	Full Name
ARI	Average recurrence interval
BMP	Best management practice
BPP	Best planning practice
LWMS	Local water management plan
PDA	*Planning and Development Act 2005* (WA)
PEA	*Planning and Environment Act 1987* (Vic)
PSP	Precinct structure plan
SLUP	Statutory land use planning
SUWM	Sustainable urban water management
UHI	Urban heat island
UWMP	Urban water management plan
WSUD	Water sensitive urban design

Chapter 1

INTRODUCTION

1.1 Background

Cities and towns require safe, healthy and reliable water supply, wastewater and drainage services. While there were notable water engineering achievements in the pre-industrial era that went some way to providing these services, such as the water supply aqueducts and drains serving ancient Rome (Evans 1997; Hodge 2002; Hopkins 2007; Lofrano and Brown 2010), the relationship between water and the city changed fundamentally during the Industrial Revolution in Europe (Abeysuriya, Mitchell, and Willetts 2006; Vuorinen, Juuti, and Katko 2007; Lofrano and Brown 2010). What Abeysuriya, Mitchell, and Willetts (2006) describe as a 'new paradigm' and Vuorinen, Juuti, and Katko (2007) as the 'second urbanisation' saw the emergence, in nineteenth century industrial European cities, of new arrangements to provide adequate supplies of water to cities, to use water to collect human waste and to convey the resulting wastewater away from urban areas. Britain led the development of these new systems, which were subsequently adopted in the United States, mainland Europe and elsewhere (Peterson 1979; Vuorinen, Juuti, and Katko 2007).

Abeysuriya, Mitchell, and Willetts (2006) suggest that this new approach to managing water and wastewater in cities was associated with a specific set of social, scientific and environmental conditions that prevailed in mid-nineteenth century British industrial cities. According to them:

1. Social conditions were typified by increasing numbers of urban poor crowding into the newly industrialising cities, where they endured filthy, insanitary conditions. Epidemics, particularly of cholera, focused attention on solving public health problems.
2. In the scientific domain, the prevailing miasma theory of disease causation favoured the removal of foul smelling materials, as 'miasmatic' malodorous air was believed to be the cause of diseases.

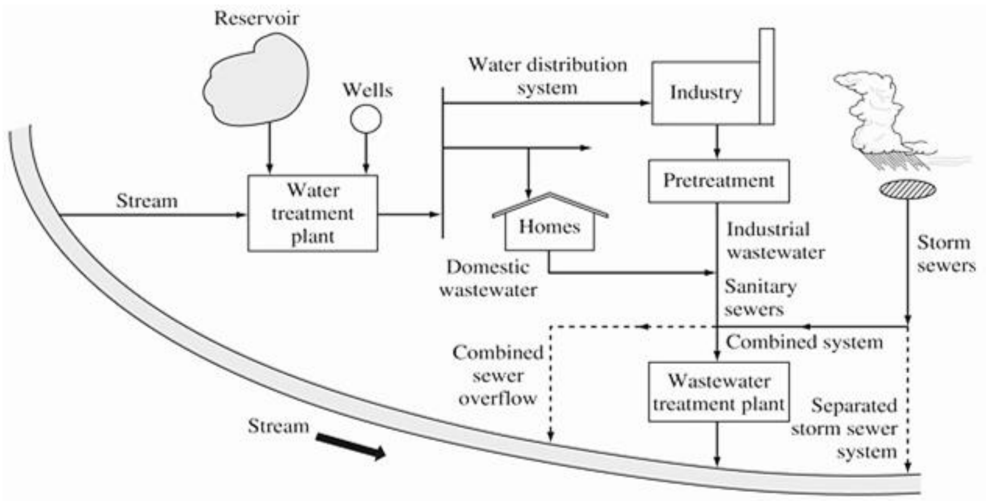
3. Water to convey wastes away from cities was readily available in the environment.

Abeysuriya, Mitchell, and Willetts (2006, 7) state that, in response to these conditions, a new ‘centralised’ paradigm to manage water in cities was devised, where:

> Centralised urban water systems use large scale infrastructures to support a ‘once through’ linear flow of water, collected from distant places, treated to a single drinking-quality standard, and transported via the reticulation network to be used once, with the resultant wastewater collected, transported, treated and disposed far from the city. Systems for providing drinking water, managing wastewater and stormwater are operated independently with minimal integration…Treatment of wastewater occurs at a central collection point at the end of the sewer network (‘end-of-pipe’ treatment).

The centralised urban water paradigm can be shown schematically[1]:

Figure 1-1: Centralised Urban Water, Wastewater and Stormwater systems



Source: Crognale 1999

Other authors support the importance, in particular, of cholera epidemics in concentrating attention on the need to improve public health in industrialising cities, in nineteenth century Europe (Harremoës 1997; Morley 2007; Mackenbach 2007; Phillips 2013).

[1] Figure 1.1 shows stormwater being conveyed by ‘storm sewers’, reflecting nomenclature used in North America. In Australia, the term ‘stormwater system’ would be used instead of storm sewers. Also refer to footnote 3.

Fortunately, despite the flawed science underlying the miasmatic theory of disease (Halliday 2001), the implementation of the new urban water and wastewater systems brought about revolutionary improvements in the health and amenity of cities (Abeysuriya, Mitchell, and Willetts 2006; Vuorinen, Juuti, and Katko 2007). The enormous impact of these changes was such that the introduction of separate urban water and wastewater systems has been identified as the most significant medical advance since the mid-nineteenth century (Ferriman 2007).

While analyses such as those of Abeysuriya, Mitchell, and Willetts (2006) and Vuorinen, Juuti, and Katko (2007) provide a useful insight into the technical factors that were associated with the introduction of new urban water management arrangements in the nineteenth century, they overlook the legal and administrative context for these changes. This is illustrated by Hamlin and Sheard (1998), who put forward a compelling case that the legislative framework provided by the *Public Health Act 1848*[2] played a key role in fostering the mid-nineteenth century changes to urban water management in England and Wales. The Act was influenced by a Royal Commission on the Health of Towns, which investigated sanitary conditions in large towns in England and Wales, and recommended ways to ameliorate the problems the Commission identified (Hamlin and Sheard 1998). The Act established a framework to provide a constant water supply to urban areas and to install sewers to carry waterborne wastes safely away from these areas (Hamlin and Sheard 1998). It also laid down administrative and financial arrangements, which ensured that the new urban water infrastructure was funded, constructed and operated effectively. Hamlin and Sheard argue that, on balance, the 1848 Act was highly effective legislation, particularly given that it was drafted when 'there were no models, no good way to choose among several defensible alternatives, and the legislation was necessarily complicated' (1998, 598). They applaud the Act as a catalyst not just for improving urban water management practices, but for the development of the wider public health

[2] *Public Health Act 1848*, 11 & 12 Vict, c 63.

movement, a conclusion supported elsewhere (Fee and Brown 2005; Morley 2007).

On this basis, the 1848 Act clearly provided a strong legislative, administrative and financial framework for the new urban water management arrangements emerging in England. This episode in history reminds us of the need to appreciate legislative and administrative arrangements governing water regimes, as well as technical aspects of water systems and urban planning.

New centralised urban water systems were also constructed in Australian cities, with results that were as dramatic as elsewhere. For example, Adelaide's annual mortality rate dropped from 23.5 per 1,000 to 14.3 per 1,000 after the completion of a sewerage system,[3] with typhoid being almost totally eliminated (Styles 1888). Sydney's annual mortality rate declined from 19 per 1,000 to 15.2 per thousand from 1888 to 1898, coinciding with the rapid expansion of the sewerage network. The greatest decline in mortality was in children under five (Bruce and Kendall 1901). In Melbourne, a comparison of the thirteen years before the introduction of a sewerage system with the subsequent thirteen years showed a reduction in annual mortality from 18 to 12.6 per thousand, with typhoid mortality reducing by 72 percent and diphtheria mortality declining by 66 percent (Cannon 1988, 175).

Continued technical advances ensured that urban water management was founded on an increasingly sound scientific basis in the decades following the mid-nineteenth century. These included, for example, the 'rational method' for relating stormwater runoff volumes, and hence the size of stormwater pipes, to rainfall (Stephenson 1981), and the development of new processes to treat wastewater more effectively (Cooper 2001; Lofrano and Brown 2010; Tilley 2011).

The large-scale, centralised urban water management model remained the dominant paradigm through most of the twentieth century (Gleick 2000).

[3] 'Sewerage system' is a collective term that refers to the system of sewers (pipes), and associated structures and treatment plants used to collect, transfer and treat wastewater. In some countries, one pipe network transports both the community's wastes and surface stormwater runoff (combined sewer systems), while others, including Australia, use separate systems to collect surface stormwater runoff (stormwater system) and domestic, industrial and commercial wastewater (separate sewerage system). Refer to Barnes et al. (1981, 51).

However, challenges to this model became apparent in the final decades of that century (Gleick 1998; Gleick 2000; Mitchell 2006). Debate about alternatives to conventional centralised arrangements was triggered by issues such as increasing awareness of the environmental impacts of the urban water industry, a new focus on efficiency improvements and water reuse, and changes to traditional demand patterns (Mouritz 1996; Gleick 1998; Gleick 2000). In Australia, the interest in new approaches to urban water management was strengthened by the long-lasting, severe and widespread Millennium Drought, which ran from 2001-2009 and remains the most severe drought on record for south-east Australia (van Dijk et al. 2013). This event led to discussions about whether fundamentally new ways of thinking about urban water in Australia were required (Grant et al. 2013).

Contributing to this debate, Brown, Keath, and Wong (2009) suggest that developments in urban water management could be represented as an evolution from the initial focus on water supply, sewerage and drainage, through periods of greater attention to the environmental health of waterways and the water cycle, to the ultimate goal of the 'water sensitive city'. This water sensitive city incorporates: 'access to a diversity of water sources underpinned by a diversity of centralised and decentralised infrastructure…provision of ecosystem services for the built and natural environment…socio-political capital for sustainability and water sensitive behaviours' (Wong and Brown 2009, 681).

Water sensitive urban design, WSUD, is said to be an integral part of the evolution of the water sensitive city (Ferguson et al. 2012). The WSUD concept suggests that, to meet multiple urban water management objectives, water planning must blend with urban planning (Water Sensitive Urban Design Research Group 1990; Mouritz 1996; Victoria. Stormwater Committee 1999; Wong and Eadie 2000). Another dimension of WSUD is said to involve moving away from the centralised urban water infrastructure shown in Figure 1-1 to a more decentralised approach, using infrastructure at a range of physical scales (Wong 2006a; Ferguson et al. 2012). Key benefits of WSUD are said to include maintaining and improving the condition of urban streams, building resilience to climate change, efficient use of water resources, and ensuring that decisions about urban water management are informed by the local social, cultural and environmental context (Mouritz 1996; Newman 2001; Mitchell 2006). This suggests that WSUD has the potential to contribute to the ecological, social and economic development of cities.

1.2 Significance of the Research

The significance of WSUD, in the Australian context, is exemplified by its inclusion in the water policy agenda of Australian governments, at the national and state/territory level. All Australian governments signed the 2004 *Intergovernmental Agreement on a National Water Initiative*, which includes commitments to identify gaps in knowledge related to WSUD and develop WSUD guidance, with the broader aim of building capacity to create water sensitive cities (Council of Australian Governments 2004; Australia. Department of Agriculture and Water Resources 2016). WSUD is explicitly referenced in regulation and policies in a number of Australian jurisdictions (Victoria. Department of Sustainability and Environment 2006; Western Australia. Western Australian Planning Commission 2008a; Western Australia. Western Australian Planning Commission 2008b; South Australia. Department of Environment Water and Natural Resources 2013). This recognition of WSUD by governments extends to its inclusion in land use[4] planning regulation and policies (Choi, McIlrath, and Williams 2015; McCallum and Boulot 2015). The recognition of, and support for, WSUD by Australian governments is discussed further in Chapter 3 of this thesis.

Notwithstanding this recognition of WSUD at the political level, it is still a relatively new concept. Knowledge and understanding of how best to encourage its adoption is still evolving. It appears that the implementation of WSUD in individual Australian jurisdictions has been ad hoc (Mitchell 2006). According to McCallum and Boulot (2015), stronger alignment of land use planning and urban water planning, to facilitate water sensitive outcomes, is needed. However, there

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[4] In Australian usage, 'land use' frequently is not hyphenated in the term *land use planning*: see, for example Gurran (2007) and Gurran (2011). However, some authors favour using a hyphen, as evidenced by Thompson and Maginn (2012). It appears that no widely agreed convention has emerged to date. The current author believes that the hyphenated form is unnecessarily complex and uses the terms *land use planning* and *statutory land use planning* in this thesis.

appears to be a lack of agreement on just what WSUD is and a knowledge gap about the relationship between land use planning and urban water management, reflecting a lack of research in this area (Sharma et al. 2012, 344). This thesis addresses these knowledge gaps.

1.3 Aims of the Research and Research Question

The fundamental aim of this thesis is to contribute to knowledge about the role that statutory land use planning[5] plays in the implementation of WSUD practices in Australian cities. The use of statutory land use planning to facilitate WSUD in Australian jurisdictions relies on two key assumptions. Firstly, the inclusion of provisions designed to encourage WSUD in the statutory land use planning regimes of Australian jurisdictions logically rests on an assumption that these regimes do in fact have the capacity to influence the implementation of WSUD to a material extent. Secondly, it can be inferred that the relevant actors in these jurisdictions also assumed there is a body of knowledge about the most effective ways for statutory planning frameworks to encourage the adoption of WSUD practices, when they designed the specific provisions intended to foster WSUD. These assumptions have not, to date, been rigorously tested via scholarly analysis. This thesis investigates these assumptions and, in doing so, enhances knowledge about the influence of statutory land use planning on the implementation of WSUD in Australia.

In order to meet its primary aim, the thesis considers the following question:

> *To what extent and in what ways does statutory land use planning in Australian jurisdictions materially influence the implementation of WSUD practices? In other words, how does statutory land use planning facilitate, or hinder, the adoption of WSUD practices?*

The answers to this question will contribute to both an improved theoretical understanding of the linkages between statutory land use planning and WSUD

[5] Statutory land use planning includes legislation, delegated legislation and quasi-legislation made by governments. The definition of statutory land use planning is discussed further in Section 3.4.1.

implementation, and to providing knowledge which will assist WSUD policy makers and practitioners.

1.4 Analytical Framework

This section of the introduction describes the analytical framework used in the research. It considers possible analytical approaches to the research question and how a specific lens was selected. It also describes how a number of individual components of WSUD practice were identified, which provide a more comprehensive analytical framework, compared with previous investigations.

The research question examines how legal instruments, in the form of statutory land use planning, affect WSUD practices. Thus, in selecting an analytical lens, we need to consider theoretical approaches to the influence exerted by legal instruments. We can note that land use planning is a form of regulation. The understanding of regulation has expanded in recent decades, due to insights such as the regulatory space concept proposed by Hancher and Moran (1989), Braithwaite and Drahos’ (2000) description of webs of influence in business regulation involving many actors and Black’s wide-ranging definition of regulation (2002; 20):

> regulation is the sustained and focused attempt to alter the behaviour of others according to defined standards or purposes with the intention of producing a broadly identified outcome or outcomes, which may involve mechanisms of standard-setting, information-gathering and behaviour-modification.

These perspectives suggest that a wide range of activities, carried out by both government and non-government actors, can be considered under the umbrella of ‘regulation’. The focus of this thesis is how statutory land use planning enacted by governments influences the implementation of WSUD and the extent to which past practices and behaviours have been modified to achieve improved outcomes.

There is an enormous literature about regulation by governments. Particularly influential ideas include complex regulatory webs (Brathwaite and Drahos 2000; Coen and Thatcher 2008; McCallum 2015) and the regulatory pyramid, which describes the responsive use of a range of regulatory tools to achieve desired objectives (Ayres and Braithwaite 1992; Braithwaite 2006; Braithwaite 2007;

Braithwaite, Makkai, and Braithwaite 2007). Another important theme is 'rethinking' regulation, typically arguing for the reduction of what is claimed to be an unduly onerous regulatory burden on the private sector (Better Regulation Task Force 2005; Regulation taskforce 2006; Radaelli and De Francesco 2007). Another approach is to categorise the regulatory tools deployed by governments (Hood 1983; Salamon and Lund 1989; Gunningham, Grabosky, and Sinclair 1998; Salamon 2002; Hood and Margetts 2007; Morgan and Yeung 2007; Baldwin, Cave, and Lodge 2011).

An approach relevant to the current study is Freiberg's scheme to identify and categorise the regulatory tools available to governments (2010; June 2010). Freiberg argues that 'Regulation is essentially about the use of power…Power, like regulation, can be regarded as the ability of A to get B to do something that he or she would not otherwise do, or not do something he or she otherwise would' (Freiberg 2010, 84). Power is then equated with the ability to control resources, which are things of cultural significance to a specific society at a specific time, leading to the conclusion that 'The tools of government are, in essence, things of cultural significance that can be concentrated or amassed and used to influence behaviour' (Freiberg 2010, 84). Based on this analysis, Freiberg identifies the following six categories of tools, which governments can use to influence behaviour (2010; June 2010):

1. Economic regulation: this includes actions such as changing access to markets, governments intervening in markets or creating markets, and altering the costs and benefits of specific actions.
2. Transactional regulation: this includes government commercial transactions with other parties and is related to economic regulation.
3. Authorisation as regulation: governments can authorise a specific action, premises or status, by a variety of means such as licences, permits and approvals.

4. Structural regulation: governments can alter the physical environment, or design processes, to direct behaviour.
5. Informational regulation: governments can provide information to overcome information asymmetries, and to modify behaviours and attitudes.
6. Legal regulation: governments introduce laws, enforced by sanctions, to direct behaviour. Laws include primary, delegated and quasi-legislation. As well as their direct role, laws also provide the necessary framework for the other categories of tools.

Freiberg's premise that the tools of government represent the deployment of resources by governments to influence behaviour was adopted in this study. When governments use statutory land use planning to encourage the adoption of WSUD practices, they seek to use the resources available to them to influence behaviour.

Beyond this, particular advantages of Freiberg's intellectual framework are that, firstly, it seeks to understand the role that laws, and other regulatory tools, play in meeting public policy objectives and secondly, it examines what effect the law actually has on social and professional practices. It aims to move beyond simply 'what the law says' to questions of public policy and to encourage the use of multiple perspectives, to provide a richer analysis.

In addition to Freiberg's insights, Chapter 2 of this thesis shows that 'WSUD' is a protean term, interpreted in different ways by different authors. As well as conceptualising WSUD for the purposes of the research, this study identifies four distinct components of WSUD practice, in order to allow a more precise examination of WSUD practices than previous investigations.

1.5 Scope and Limitations

The preceding section indicated that a range of regulatory tools can be used to achieve desired outcomes. It seems likely that, for example, public health and environmental regulation influences WSUD outcomes, in addition to statutory land use planning (McCallum and Boulot 2015). Chapter 3 reviews a broad range of factors, including regulatory frameworks, technical constraints, financing, acceptance of WSUD, capacity building and the wider socio-political context, said to influence the adoption of WSUD practices. While acknowledging the potential for a range of factors to affect the implementation of WSUD, the research question in this thesis specifically relates to the influence of statutory land use planning on the implementation of WSUD. The objective of this study was, as far as possible, to isolate and investigate how statutory land use planning influences WSUD practices.

The empirical research does seek to place the influence of statutory land use planning in context, by examining whether it is an important influence on WSUD practices. However, this assessment does not compare the influence of statutory land use planning with other factors. This is a limitation of the research.

The research question was investigated empirically. Empirical research methods used in social inquiries, typically have strengths and limitations (Bryman 2015). Instead of relying on a single method, the research design used in this investigation included both a survey and a series of case studies. This approach provided information from a range of sources, including the survey, analysis of documents identified in the case studies and the analysis of case-study interviews. The survey and the case studies collected qualitative and quantitative information. This range of sources and types of information was intended to enhance the reliability of the research findings. The strengths and limitations of the methods used to collect and analyse information are discussed in more detail in Chapter 4, which considers the overall design of the research described in this thesis, Chapter 5, which discusses the survey and Chapter 6, which examines the design of the case studies.

The research reported in this thesis relates to the influence of contemporary statutory land use planning systems on WSUD practices, in the Australian context. As the cultural, political, technical and legal environment for WSUD evolves over time, the research findings may become less current. It is intended that the research will inform the development of Australian statutory land use planning regimes, so they better support the adoption of WSUD practices.

1.6 Thesis Structure

This chapter briefly described the development of modern urban water management ideas, including the recent introduction of the WSUD concept.

Chapter 2 focuses on the WSUD concept. The chapter examines the origin, development and current understandings of the term at some length. This discussion includes the emergence of the notion of sustainable development, the links between this notion and a re-evaluation of urban water management, the inception and evolution of the WSUD idea, and how WSUD relates to other innovative urban water management concepts. The chapter articulates the definition of WSUD used in this thesis and identifies four specific components of WSUD practice, which provide a useful basis for subsequent analysis.

Chapter 3 examines the primary influences that affect WSUD practices. It reviews reported influences on WSUD, including land use planning, and considers possible links between the broader socio-political environment and the implementation of WSUD. A number of shortcomings in previous research are identified, which are addressed by the research reported in this thesis. This chapter also defines statutory land use planning, for the purpose of this research, outlines the allocation of land use planning responsibilities in Australia's federal system of government and describes the specific statutory land use planning settings for WSUD in Australian jurisdictions.

Chapter 4 articulates the design of the empirical research reported in this thesis. It discusses possible ways to investigate the research question and how a research design, incorporating appropriate methods, was developed. The research design includes procedures to collect and analyse data, in order to provide answers to the research question. The chapter also considers the potential to apply the research findings beyond the specific circumstances of this investigation to other settings, that is, to generalise the findings.

Chapter 5 describes the planning, implementation and results of a survey of participants from the government, water utility, private and research sectors, about the influence of statutory land use planning on WSUD practices.

Chapters 6, 7 and 8 relate to case studies, which examine the influence of statutory land use planning on WSUD practices at four Australian residential developments. These chapters outline the design of the case study research (Chapter 6), and describe case studies in Victoria (Chapter 7) and case studies in Western Australia (Chapter 8).

Chapter 9 uses the results of the survey and the case studies to examine hypotheses about how statutory land use planning influences WSUD practices

Chapter 10 examines how the Victorian and Western Australian statutory land use planning systems interpret the WSUD concept differently. It also considers how statutory land use planning provisions could be varied, to better encourage the adoption of WSUD practices.

Chapter 11 summarises the research findings and shows how they answer the research question. Potential areas for further research are also identified.

Chapter 2

THE WATER SENSITIVE URBAN DESIGN CONCEPT

2.1 Introduction

This chapter describes the development and evolution of the WSUD concept and its connections with the broader debate about sustainable urban water management. The chapter firstly examines the origins of the idea of sustainable development. It then describes how the growing interest in sustainable development coincided with a reassessment of contemporary urban water management practices and the emergence of new approaches to managing urban water in the late twentieth century.

Section 2.4 articulates the origin and subsequent evolution of WSUD. It shows that WSUD is a contested idea and identifies key aspects that are disputed. The definition of WSUD adopted for the research is then set out in section 2.5. Section 2.6 identifies a number of components of WSUD practice, which provide a novel framework for the empirical research. Section 2.7 compares WSUD with a range of other urban water management ideas proposed around the turn of the century, identifying key similarities and differences between them. Section 2.8 provides a summary of the chapter's main arguments.

2.2 The Rise of Sustainability

Van Zon, cited in Du Pisani (2006, 85), states that demands for raw materials, and the environmental impacts associated with those demands, have been present throughout human history. According to Van Zon, the ancient Egyptian, Mesopotamian, Greek and Roman civilisations encountered problems such as deforestation and loss of soil fertility, and considered practices to mitigate the associated impacts.

Du Pisani describes the rise in Western thinking, after the Greco-Roman classical period, of the concept of 'progress' as the precursor to the idea of development. Du Pisani states that the idea of progress driving the material and moral improvement of humanity became a dominant part of the Western intellectual worldview during the Enlightenment and its aftermath through to the nineteenth century (2006, 84). This vision of progress was linked with scientific and technological progress, and humanity's right to subjugate the natural world to maximise material benefits (Du Pisani 2006).

That said, some isolated commentators did question the implications of unconstrained material progress. In his famous 1798 publication, *An Essay on the Principle of Population,* Thomas Malthus suggested that population growth would be limited by available resources. John Stuart Mill's *Principles of Political Economy* (1848) refers to the 'stationary state', that 'implied a stationary condition of capital and population, but not of human improvement' (Du Pisani 2006, 86). Alfred Russel Wallace's 1898 survey of the nineteenth century, *The Wonderful Century Its Successes and Its Failures,* includes a chapter on the despoliation of the Earth caused by unrestricted extraction of resources. More than a century later, Van Zon concluded that ideas about sustainability described in the 1987 Brundland Report had already been foreshadowed by Wallace (Van Zon 2002).

After the cataclysms of two world wars and the Great Depression, economic growth resumed in the developed world from the middle of the twentieth century. NcNeill (2000) states that, if economic growth is considered from 1500 to the late twentieth century, the most rapid growth occurred from 1950 to 1973. From 1800 to 1970, the global population increased from around 978 million to 3,632 million and manufactured output grew around 1,730 times (Rostow 1978). In summary, population, economic output and the consumption of resources reached unprecedented levels during the twentieth century.

Alongside this material advance, a more critical view of the concept of unlimited development and economic growth also occurred in the second half of the twentieth century (Du Pisani 2006). Concerns about overstressed ecosystems, wasted resources and contaminated environments found new levels of public support in the 1960s (Weiland 1996).

As the environmental debate continued into the 1970s, the Club of Rome became an influential voice (Colombo 2001). This 'think tank', founded in 1968 by a group of industrialists, scientists and academics, was concerned with the long-term implications of unfettered economic growth (Moll 1991). The Club examined the relationship between, on the one hand, continued population growth and economic growth and, on the other, what were assumed to be finite resources in its *Limits to Growth* report (Meadows et al. 1972). The report considers the interactions between population growth, industrial production, pollution, food production and the consumption of non-renewal natural resources. The report identifies the possibility of demand for natural resources exceeding their availability and the need to avoid this by a collective commitment to achieving global equilibrium (Colombo 2001, 7). The model supporting the report links the world's economy and environment and is the first integrated global model (Constanza et al. 1972). The *Limits to Growth* report helped to coalesce a range of inchoate anxieties into a more coherent discussion of alternative visions of progress (Kenny 1994).

The Club's concepts of limits to natural resources, and the need for society to acknowledge and adapt to them, could be seen to sit uneasily with industries such as the urban water sector which relied, at that time, on supply-side augmentation to meet what were assumed to be inexorably rising demands for services. Responses to the *Limits to Growth* were varied, disparate and often lively (Colombo 2001). That said, the idea of a potential collision between open-ended population and economic growth, on the one hand, and, on the other, finite natural systems was firmly established as a topic for intellectual and political debate (Moll 1991).

In a perceptive analysis, Mitcham (1995) argues that the debate about environmental issues fundamentally shifted when it moved from considering what <u>should not</u> be done, such as exceeding the globe's limits to growth, to considering what <u>should</u> be done. Mitcham states that the driving forces in altering the framework for debate were the release of the *World Conservation Strategy* by the International Union for Conservation of Nature (1980) and *Our Common Future* (the Brundtland Report) by the United Nations World Commission on Environment and Development (1987).

The *World Conservation Strategy* addresses the conservation of natural resources and recommends policies for national and international action. Its definition of development refers to the application of resources and the modification of the biosphere to meet human needs. It recommends that, for 'development to be sustainable, it must take account of social and ecological factors, as well as economic ones; of the living and non-living resource base and of the long term as well as the short-term advantages and disadvantages of alternative actions.' (1980, 1). Conservation is defined as (1980, 1) 'the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations'.

With its emphasis on maintaining the potential to meet the needs of future generations, this definition does not adopt a 'limits to growth' philosophy, with the associated prospect of a society in stasis and constrained prospects for future growth and development.

Ensuring that the needs of future generations could be met is also a key theme in the Brundtland Report (World Commission on Environment and Development 1987). The report is broadly concerned with reconciling the aspirations of populations in less developed countries for improved material conditions with the protection of global ecological processes. It attempts to harmonise these demands by defining sustainable development as (1987, 43):

> development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Brundtland explicitly rejects the existence of immediate limits to growth, which would constrain the improvement of conditions in less developed countries, while acknowledging the existence of some ultimate limits (1987, 45):

> Growth has no set limits in terms of population or resource use beyond which lies ecological disaster. Different limits hold for the use of energy, materials, water, and land. Many of these will manifest themselves in the form of rising costs and diminishing returns, rather than in the form of any sudden loss of a resource base. But ultimate limits there are, and sustainability requires that long before these are reached, the world must

> ensure equitable access to the constrained resource and reorient technological efforts to relieve the pressure.

Brundtland also considers that sustainable development is not simply a technical process and that achieving such growth also requires appropriate political, economic, social, financial and administrative measures[6]. This addition of broader social and economic dimensions is claimed to have addressed a significant gap in the World Conservation Strategy's sustainable development formulation (Pearce, Barbier, and Markandya 1990, ix). The Brundtland Report was highly influential (Pearce, Barbier, and Markandya 1990; National Research Council (US) Policy Division Board on Sustainable Development 1999) representing 'a watershed in thinking on environment, thinking and governance' (Sneddon, Howarth, and Norgaard 2006, 253) and 'a vital historical marker' (Sneddon, Howarth, and Norgaard 2006, 255).

Notwithstanding the Brundtland Report's influence, its approach to sustainable development has been the subject of much debate (Washington State University n.d.). According to Mitcham (1995), conservative commentators make the criticism that sustainable development implies stasis, which will eventually be overwhelmed by population growth and increased demand, whereas progressive critics suggest that it provides a mechanism to protect vested interests and prevent reforms to the global economic and political order. Du Pisani (2006) highlights the contrasting views of neoclassical and environmental economists about sustainable development. According to Du Pisani, neoclassical economists argue that there can be trade-offs between different forms of capital (physical, human and natural) to support growth. This provides weak sustainability, because a reduction in natural capital can be compensated by increases in other forms. In contrast, environmental economists favour strong sustainability, where the stock of natural capital must be maintained.

[6] The claim that sustainable development extends beyond the technical realm is discussed throughout the Brundtland Report. In particular, Chapter 12 emphasises the need for action at the legal and institutional level.

Sneddon, Howarth, and Norgaard (2006) review the post-Brundtland discourse. They point out that sustainable development has been critiqued from a very diverse range of disciplines and political viewpoints, and by a very wide range of actors. They are therefore not surprised that a single, broadly accepted interpretation of sustainable development, and a corresponding agenda for its implementation, have failed to coalesce. Sneddon, Howarth, and Norgaard suggest that sustainable development can be approached from a number of perspectives, including ecological economics, political ecology and 'development as freedom', which provide differing, but complementary, epistemological and normative ideas. Sneddon, Howarth, and Norgaard correctly recognise that the concept of sustainable development is interpreted by a wide range of commentators, with a corresponding range of worldviews. This approach provides a way to reconcile, and acknowledge the value of, these disparate interpretations of the sustainable development idea and is persuasive.

The influence of the Brundtland Report extended to Australia, as evidenced by the adoption of a *National Strategy for Ecologically Sustainable Development* by the Australian Government and all State and Territory Governments in 1992 (Australia. Ecologically Sustainable Development Steering Committee 1992). The introduction to the Strategy states that its origins can be traced to the *World Conservation Strategy*, the *National Conservation Strategy for Australia* (1983) and, significantly, the Brundtland Report. The Strategy defines ecologically sustainable development as (Australia. Ecologically Sustainable Development Steering Committee 1992, 6):

> using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.

According to Mouritz (1996, 46), the term 'ecologically sustainable development' (ESD) was adopted because of a belief that 'sustainable development' did not place sufficient emphasis on ecological processes.

The international political significance of the sustainability concept was demonstrated by the participation of 172 governments at the 1992 United Nations

Conference on Environment and Development (UNCED), held in Rio de Janiero. According to a committee of the Victorian Parliament, sustainability became part of the global political agenda at UNCED (Victoria. Parliament. Outer Suburban Interface Services Development Committee 2004, 11). Phillips (2003) states that UNCED acknowledged the nexus between the environment and development, a fundamental component of the Brundtland sustainable development concept.

In 2002, the United Nations convened the World Summit on Sustainable Development (WSSD) in Johannesburg. According to Von Frantzius (2004), the outcomes of WSSD largely overlapped with previous commitments intended to promote sustainable development, with WSSD's most useful achievement being to more closely link the social and economic aspects of sustainable development with environmental goals. This indicates that the generally accepted principles of sustainable development did not change significantly at WSSD.

In summary, the idea of sustainable development, articulated in the landmark Brundtland Report in 1987, was the result of an evolutionary pathway that lead from early ideas of material progress, to the emergence of widespread concerns about resource exploitation and environmental degradation in the 1960s and 1970s, and ultimately to efforts to reconcile economic growth with protecting ecological processes in the latter part of the twentieth century. Notwithstanding debate about the interpretation and merits of the sustainable development concept, that concept has been immensely influential and 'is now firmly entrenched within many government offices, corporate boardrooms, and the hallways of international NGOs and financial institutions' (Sneddon et al. 2006, 259).

The next section shows how 'sustainability' influenced the objectives for urban water systems late in the twentieth century, helping to promote the emergence of what was described as a new urban water paradigm.

2.3 Traditional Urban Water Service Models and the Need for Innovation

Reassessing Urban Water Management

The development of large-scale, centralised urban water systems in the nineteenth century to provide water supply, wastewater and drainage services in cities and towns was described in section 1.1. These systems provided enormous public health and amenity benefits, and this service model was considered to represent successful conventional practice throughout most of the twentieth century. However, this approach to urban water servicing started to be reassessed in the latter part of that century, coinciding with the increasing prominence of sustainable development ideas.

A salient example of this reassessment was the emergence of an Integrated Urban Water Management (IUWM) model during the 1970s and its widespread acceptance over the following two decades (Marsalek, Rochfort, and Savic 2001). The initial focus of this 'integration' was on viewing potable water supply, wastewater collection and treatment, and stormwater conveyance as individual elements of an integrated cycle. McPherson (1973) recommended applying a water balance approach to assess the fate of water as it cycles through a metropolitan area. This recommendation 'implied the need for a more holistic and integrated understanding of the way water supply, sanitation and drainage systems operated' (Mitchell 2006, 590).

The IUWM concept significantly evolved in the late twentieth century to reflect new sustainability objectives, technical advances and new ideas about the actors who should contribute to urban water management (Mouritz 1996; Niemczynowicz 1999; Pinkham 1999; Gleick 2000; Chocat et al. 2001; Mitchell 2006). From a sustainability perspective, the protection of ecological processes was recognised as a key management objective, to be added to the protection of public health and urban amenity (Mouritz 1996; Gleick 2000, 131; Chocat et al. 2001, 62; Mitchell 2006, 590). New technical ideas included using demand management to complement or replace supply augmentations (Niemczynowicz 1999, 7; Pinkham 1999, 5; Glieck 2000, 131; Mitchell 2006, 591); utilising non-traditional water sources, such as treated stormwater and wastewater (Niemczynowicz 1999, 4; Pinkham 1999, 5; Gleick 2000, 134-135; Mitchell 2006, 591) and adopting new treatment technologies based on biological processes and decentralisation i.e. the use of small-scale, physically dispersed infrastructure[7] (Niemczynowicz 1999, 3; Pinkham 1999, 5-6; Mitchell 2006, 590). New decision-making models advocated consultation within and between agencies and engagement with the community to foster more robust decision making (Mouritz 1996; Niemczynowicz 1999, 4; Pinkham 1999, 6; Mitchell 2006, 590). These new ideas broadened the scope of IUWM beyond its previous focus on the more efficient operation of centralised infrastructure.

Another term, 'sustainable urban water management', 'SUWM', which appeared around the end of the twentieth century, largely overlapped with the interpretation of IUWM described in the previous paragraph. For example, Larsen and Guyer (1997) consider how the sustainable development concept that emerged from the Brundtland Report and the United Nations Rio Conference could be applied in the urban water context in order to achieve SUWM. A sustainable urban water management program was initiated in Sweden in 1999, as a response to the need to add sustainability to the protection of public health and amenity as objectives for urban water systems (Hellström, Jeppsson, and Kärrman 2000). When Brown, Keath, and Wong (2009) examine the evolution of urban water management in cities, culminating in the 'water sensitive city', they indicate that the evolutionary pathway they describe would result in progressively more comprehensive implementation of SUWM. Both SUWM and late twentieth century descriptions of IUWM include sustainability as an explicit objective for

[7] The concept of centralised urban water systems was discussed in section 1.1. 'Decentralisation' refers to installing water, wastewater and stormwater systems at a range of scales, including on-site systems that service individual properties; cluster scale systems that service two or more properties that form a discrete cluster; and distributed systems that serve a large number (more than 100) properties (Diaper, Tjandraatmadja, and Kenway 2007; Sharma et al. 2013). The term decentralised systems is well recognised in the urban water sector and is used in this thesis to describe water, wastewater and stormwater systems physically dispersed at a range of scales, in contrast to the large-scale, highly centralised systems that were regarded as conventional practice until the turn of the century. Nonetheless, it should be acknowledged that it is difficult to identify a precise scale, based on number of properties or population served, to differentiate centralised and decentralised systems (Sharma et al. 2013, 2096).

urban water management and can be regarded as synonymous. Accordingly, the single term IUWM will be used hereafter in this thesis.

Interpreting New Approaches to Urban Water Management

The emergence of these new assumptions, expectations and modes of thinking about urban water management provoked debate about whether they represented an evolution of previous practices, or exemplified a more fundamental shift, which could be characterised as the emergence of a new paradigm.

The evolutionary interpretation is favoured by Chocat et al. (2007), who note that alternatives to conventional stormwater management practices were already being investigated in the 1970s. They point out that principles to mitigate the impacts of stormwater had been formulated in that decade and implemented, for example, at the Woodlands, Texas, Planned Community. This development used a stormwater system that incorporated small-scale detention ponds and porous pavements to control stormwater runoff rates and utilise stormwater for recreational and aesthetic purposes (Dinez and Espey 1979). This early alternative to conventional centralised water servicing did overlap with IUWM concepts. It should be acknowledged that the development of techniques to detain and manage urban stormwater locally, instead of by large centralised infrastructure, occurred in the early 1980s in a range of countries, including France, Germany and the United States (Fletcher et al. 2014). Also, in Canberra, Australia, some changes to stormwater management took place in the 1970s, including efforts to better integrate drainage pathways with the landscape and to treat stormwater, to protect the environmental values of inland waters (Lawrence 2001).

However, in contrast to Chocat et al. (2007), Pinkham (1999) and Gleick (2000) argue that a new urban water paradigm was emerging. Pinkham, for example, provides a useful summary of this suggested new paradigm:

Table 2-1: Characteristics of the Old and New Urban Water Management Paradigms

Old Paradigm	New Paradigm
Human waste is a nuisance. It is to be disposed of after the minimum required treatment to reduce its harmful properties.	*Human waste is a resource.* It should be captured and processed effectively, and put to use nourishing land and crops.
Stormwater is a nuisance. Convey stormwater away from urban areas as rapidly as possible.	*Stormwater is a resource*. Harvest stormwater as a water supply, and infiltrate or retain it to support urban aquifers, waterways, and vegetation.
Build to demand. It is necessary to build more capacity as demand increases.	*Manage demand.* Demand management opportunities are real and increasing. Take advantage of all cost-effective options before increasing infrastructure capacity.
Demand is a matter of quantity. The amount of water required or produced by water end-users is the only end-use parameter relevant to infrastructure choices. Treat all supply-side water to potable standards, and collect all wastewater for treatment in one system.	*Demand is multi-faceted.* Infrastructure choice should match the varying characteristics of water required or produced by different end-users: quantity, quality (biological, chemical, physical), level of reliability, etc.
One use (throughput). Water follows a one-way path from supply, to a single use, to treatment and disposal to the environment.	*Reuse and reclamation.* Water can be used multiple times, by cascading it from higher to lower-quality needs (e.g. using household graywater for irrigation), and by reclamation treatment for return to the supply side of the infrastructure.
Grey infrastructure. The only things we call infrastructure are made of concrete, metal and plastic.	*Green infrastructure*. Besides pipes and treatment plants, infrastructure includes the natural capacities of soil and vegetation to absorb and treat water.
Bigger/centralized is better. Larger systems, especially treatment plants, attain economies of scale.	*Small/decentralized is possible, often desirable.* Small scale systems are effective and can be economic, especially when diseconomies of scale in conventional distribution/collection networks are considered.
Limit complexity: employ standard solutions. A small number of technologies, well-known by urban water professionals, defines the range of responsible infrastructure choices.	*Allow diverse solutions.* A multiplicity of situation tuned solutions is required in increasingly complex and resource-limited urban environments, and enabled by new management technologies and strategies.
Integration by accident. Water supply, stormwater, and wastewater systems may be managed by the same agency as a matter of local historic happenstance. Physically, however, the systems should be separated.	*Physical and institutional integration by design.* Important linkages can and should be made between physical infrastructures for water supply, stormwater, and wastewater management. Realizing the benefits of integration requires highly coordinated management.
Collaboration = public relations. Approach other agencies & public when approval of pre-chosen solutions is required.	*Collaboration = engagement.* Enlist other agencies and the public in the search for effective, multi-benefit solutions.

Source: Pinkham (1999), 5-6

Pinkham (1999) refers to the emergence of a ‘soft path’ for urban water infrastructure. According to Pinkham, this is analogous to the soft path for energy infrastructure proposed by Lovins (1977), which includes demand management and a diverse portfolio of decentralised, renewable energy sources.

The merits of some of the specific characteristics Pinkham associates with his old paradigm can be debated. For example, *Integration by accident* implies that, under the old paradigm, integration at the management or physical levels was not actively pursued. However, such integration, at least in the management sense, had already been encouraged under early interpretations of IUWM as long ago as the 1970s (McPherson 1973). *Grey infrastructure* indicates that old paradigm infrastructure consisted entirely of non-biological materials, whereas conventional centralised sewage treatment includes biological processes (Barnes et al. 1981, 370). *Collaboration = public relations* overlooks the long-held awareness by government agencies that meaningful consultation is desirable for public works (Arnstein 1969). That said, Pinkham does provide 'perhaps the most succinct illustration of the difference between the 'old' and the 'emerging' paradigm', as Pahl-Wostl et al. (2011, 843) put it.

Importantly too, Pinkham's new paradigm in Table 2.1 incorporates elements of the Brundtland Report's sustainable development idea. Managing demand, recycling stormwater and cascading water through multiple uses are processes that reduce water extractions and help to protect the integrity of aquatic ecosystems, for current and future generations. Treating human waste as a resource reduces the impacts of polluted discharges on receiving environments, improves agricultural productivity and reduces the use of chemical fertilisers. Broader collaboration between management agencies, and between them and the public, is consistent with the social inclusion that Brundtland saw as an integral part of sustainable development.

Pahl-Wostl et al. (2011) provide a compelling analysis of whether the new approaches to water management discussed by authors such as Pinkham (1999) constituted a 'paradigm shift', as originally defined by Kuhn (1962). Although Pahl-Wostl et al. consider water resource management as a whole, their conclusions should be relevant to urban water management, as factors such as the inclusion of sustainability as a management objective, increasing population pressure and an increased focus on integration apply to both. Pahl-Wostl et al. conclude that it is appropriate to speak of a paradigm shift in water management, but also note that change in both science and practice has been slow (2011, 852).

The identification of a paradigm shift by Pahl-Wostl et al. (2011) is correct. This new paradigm, which emerged in the late twentieth century, represented a very large step change from previous urban water practices, which focused on protecting public health and relied on separate, centralised water supply, wastewater and stormwater systems. The new paradigm incorporates sustainable development principles, such as protecting ecological processes, conserving resources and broadened decision making.

The emergence of this paradigm encouraged efforts to consider the complete urban water cycle and not just stormwater; to manage demand; to look at opportunities to capture, treat and reuse water on a fit for purpose basis[8]; and to broaden the range of actors involved in urban water governance. Thus, the new paradigm, with its emphasis on sustainability, provided a new, broader lens to evaluate the urban water cycle and helped to stimulate the development of new urban water concepts.

The following section describes how the re-evaluation of the urban water cycle late in the twentieth century coincided with the emergence of WSUD.

2.4 The Long and Winding Road: The Development of the Water Sensitive Urban Design Concept

This section examines the inception of the WSUD concept and its later development. The initial rationale, assumptions and aspirations of WSUD are examined. The subsequent debate about the interpretation of WSUD is reviewed, showing that 'WSUD' was, and continues to be, a contested idea. This discussion informs the definition of WSUD that is adopted later in this chapter.

Origins of the WSUD Concept

The initial descriptions of the WSUD concept approximately coincided with the emergence of a range of other novel approaches to urban water management, including:

1. Low impact development/Green infrastructure (Prince George's County. Department of Environmental Resources 1997; Prince George's County.

[8] The term 'fit for purpose' refers to 'matching water type to use in order to minimise health risk and treatment requirements' (Barton and Argue 2009, 814). Examples could include capturing and treating household wastewater and reusing the treated water to flush toilets, and capturing and treating stormwater runoff and using the treated water to irrigate sporting fields. In both cases, the treated water would replace the use of drinking water. The potential benefits of a fit for purpose approach include 'the reduction in the quantity of water imported to and exported from cities, reduction in pollutants discharged to the environment and increasing the water resources available without further river regulation or groundwater pumping' (Mitchell, Mein, and McMahon 2002, 32).

Department of Environmental Resources 1999; United States Environment Protection Agency 2000)

2. Low impact urban design and development (van Roon 2005; van Roon et al. 2006; van Roon 2011)
3. Total urban water cycle management (Lawrence et al. 1999)
4. Sustainable urban drainage systems (Butler and Parkinson 1997; Andoh and Iwugo 2002; National SUDS Working Group 2004; Woods-Ballard et al. 2007)
5. Water sensitive planning (Carmon, Shamir, and Meiron-Pistiner 1997; Carmon and Shamir 2010).

This list demonstrates the extent of the international intellectual project to reconceptualise urban water management. The content of these models and their relationship with WSUD is examined in section 2.7, later in this chapter.

It is not surprising that the development of new urban water management models included the Australian contribution of WSUD. The importance of urban water policy, particularly water security, in Australia has been a constant throughout the era of European settlement. The Australian hydrologic environment, as well as that of southern Africa, is markedly different from that of the Northern Hemisphere: 'within the same climate zones, annual flow variability of these Southern Hemisphere continents is two to four times that of northwest Europe and North America' (Thomas and Bates 2002, 54). Compared to Europe, an average storage volume must be six times greater in Australia to provide the same yield, before considering the higher evaporation in Australia (Finlayson and McMahon 1988).

In this context, the term WSUD was coined in Perth, the capital of Western Australia, during the 1980s. The factors driving an acute awareness of urban water management practices were as significant in Perth, as elsewhere in Australia. Perth is located in the south-west of Western Australia and has a Mediterranean climate, with very hot summers, mild wet winters and a highly seasonal rainfall, with 80% of total rainfall being received during the six months from May to October (Timbal, Arblaster, and Power 2006). As well as this strong seasonal variability, a long-term decline in rainfall is noted in a 2009 assessment, which shows that rainfall from May to October, in south-west Western Australia, had decreased by more than 10% since the mid-1970s, while streamflows declined by 50% over the same period (Western Australia. Department of Water 2009).

The mid to late 1980s saw a growing awareness in Western Australia of the adverse impacts of urban development on the water cycle, such as damage to wetlands, changes to groundwater regimes and pollution of stormwater runoff, with these impacts likely to be exacerbated by forecast strong population growth (Mouritz 1996). According to Mouritz (1996), this increased awareness led to an examination of alternatives to conventional urban water servicing in Perth. A group was convened in 1987 in the Planning School at Perth's Curtin University, to 'investigate the scope and potential of design initiatives to optimise water conservation, water balance and water quality values within the development process' (Mouritz 1996, 226). The group considered how to link the development process with what Mouritz (1996) described as 'Integrated Urban Water Management' principles, such as considering the total urban water cycle; managing stormwater by storage and retention, instead of conveyance; considering water efficiency; and shifting from centralised to decentralised infrastructure to enhance reuse and recycling opportunities. These principles align closely with the characteristics of the new urban water paradigm proposed by Pinkham (1999), shown in Table 2.1. This alignment supports the view that WSUD was part of a transition from the previously accepted centralised urban water management model to a new paradigm, which includes sustainability as a core objective.

Table 2.2 shows the chronology of the initial development of the WSUD concept, starting with the convening of the working group at Curtin University:

Table 2-2: Steps in the Initial Development of the WSUD Concept

Year	Action
1987	WSUD interest group convened at Curtin University.
1988	Group becomes an official research committee of the West Australian Water Resources Council. Draft Water Sensitive Design Policy produced and circulated to stakeholders.
1990	The interest group, now named the Water Sensitive Urban Design Research Group, releases a report *Water Sensitive Residential Design: An Investigation into its Purpose and Potential in the Perth Metropolitan Region.*
1991	Consultants commissioned to prepare WSUD guidelines.
1994	Guidance document *Planning and Management Guidelines for Water Sensitive Urban (Residential) Design* released.

Source: adapted from Mouritz (1996)

The term WSUD was coined around 1987, when the WSUD interest group was convened (Mouritz 1996, 227) and was included in a publication by the Water Sensitive Urban Design Research Group (1990, iii):

> The aim of this report is to develop a concept of "Water Sensitive Urban Design" which takes into account water balance, water quality and water consumption issues as a basis for the planning and design of residential developments.

The Australian origin of the term WSUD identified in this thesis is supported by a literature review of global sustainable stormwater management practices (Embertsen 2012) and a review of urban stormwater management nomenclature (Fletcher et al. 2014).

A synthesis of the work of Whelans, Maunsell Halpern Glick and Thompson Palmer[9] (1994) and the varied ideas presented by Mouritz (1996), who was a participant in the early work at Curtin University,[10] indicates that the application of WSUD should include:

1. Setting multiple objectives for urban water management, including objectives relating to ecosystem protection and amenity, as well as the traditional water supply, sewerage and drainage objectives

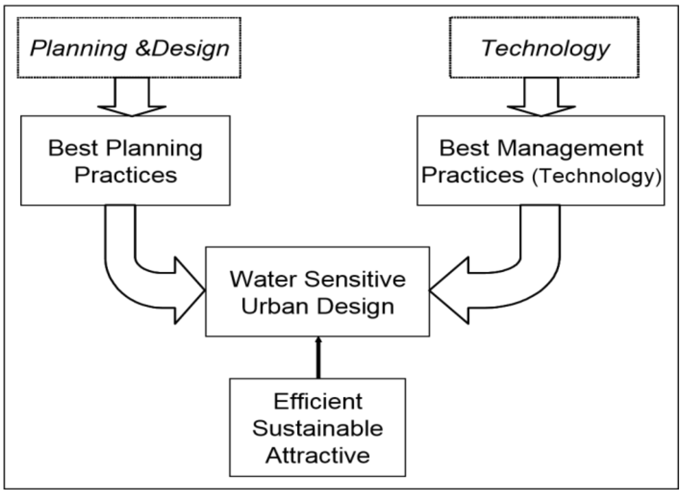
[9] Whelans, Maunsell Halpern Glick and Thompson Palmer are the names of the two consulting firms that prepared the report cited here.
[10] Personal communication with Mike Mouritz, 6 May 2014, on file with the author.

2. Selecting appropriate land use planning measures, such as controls on public open space, road layout and streetscape, referred to as 'Best Planning Practices'
3. Selecting appropriate water infrastructure options, referred to as 'Best Management Practices'
4. Using the planning system to ensure that the Best Management Practices (BMPs) and Best Planning Practices (BPPs) are implemented when development occurs.

Whelans, Maunsell Halpern Glick and Thompson Palmer advocate a philosophy that 'regards water resource management holistically and identifies water resource issues early in the planning process' (1994, 8).

The idea of using both urban planning procedures (via 'Best Planning Practices') and technical water management solutions (via 'Best Management Practices') to achieve WSUD outcomes may be shown schematically:

Figure 2-1: Use of Best Planning Practices and Best Management Practices to Achieve WSUD Outcomes



Source: Adapted from Whelans, Maunsell Halpern Glick and Thompson Palmer (1994, 5)

Mouritz states that WSUD provides 'an approach to urban planning which incorporated water resource and related environmental management into the planning process at various scales and time horizons' (1996, 208) and 'a framework of objectives and a way of linking the application of BPPs and BMPs to the urban planning process' (1996, 214). The idea of using land use planning to mitigate the potential adverse effects of urban development on the water cycle is supported by the Water Sensitive Urban Design Research Group (1990).

An aspect of the initial WSUD concept that merits examination is the urban water streams it included. The urban water cycle encompasses a range of individual water streams, including rainwater falling on the urban area, water captured elsewhere and imported to the city, stormwater runoff, wastewater, groundwater, urban waterways and the interactions between the various streams. While Mouritz (1996) acknowledges that the initial development of the WSUD concept mainly focused on improving stormwater management, he also says that it provided a framework to improve the management of the urban water cycle more generally, including facilitating water conservation and reuse opportunities. Debate about the urban water streams that WSUD includes has continued since the concept was first put forward, without being resolved. This is further discussed, later in this section.

Acceptance of the WSUD Concept in Australia

Following the initial development of WSUD in Western Australia, the concept gained acceptance elsewhere in Australia in the early years of the current century. This was reflected in the release, for example, of national guidance for applying water sensitive principles to road design in 2000 (Wong, Breen, and Lloyd) and 2003 (Wong, Fletcher, and Mag), a paper that considered how to move WSUD from the conceptual to the implementation stage in 2000 (Wong) and information about a stormwater-based approach to WSUD implementation in 2002 (Lloyd, Wong, and Chesterfield). The publication of national guidance was accompanied by the release of publications intended to foster the adoption of WSUD practices by state and local governments (Fletcher, Deletic, and Hatt 2004, 5-6).

A significant step in WSUD's recognition by Australian governments was its inclusion in the *Intergovernmental Agreement on a National Water Initiative*, endorsed by the Australian Government and all state and territory governments in June 2004, except for Tasmania, which signed the Agreement in 2005 and Western Australia, which signed in 2006 (Council of Australian Governments 2004;

Australia. Department of Agriculture and Water Resources 2016). Clause 92 of the Agreement refers to enhancing Australia's ability to create water sensitive cities, by measures including preparing public health and environmental guidelines to support water sensitive urban designs (Clause 92 (i)); developing national guidelines to evaluate water sensitive urban developments (Clause 92 (ii)); and evaluating leading examples of existing water sensitive urban developments (Clause 92 (iii)). The Agreement includes the following definition of WSUD:

> ***water sensitive urban design*** – the integration of urban planning with the management, protection and conservation of the urban water cycle, that ensures urban water management is sensitive to natural hydrological and ecological processes

With all Australian jurisdictions having signed the *Intergovernmental Agreement on a National Water Initiative* by 2006, WSUD was clearly on the national urban water policy agenda.

Varied Interpretations of WSUD

Despite this high-level political recognition of WSUD, there were competing interpretations of the concept. In 2004, McAlister, Coombes, and Barry sounded a precautionary note, when they discussed the application of WSUD to urban water management projects in South-East Queensland. They considered that the stormwater element of WSUD had come to dominate what had originally been a holistic concept covering the urban water cycle. They stated that the term 'Integrated Water Cycle Management' was replacing what had previously been referred to as WSUD. McAlister, Coombes, and Barry (2004) indicated that the issue of whether WSUD is a stormwater management concept, or applies to the broader urban water cycle, had not been resolved at that time.

Aiming for a more expansive approach, Wong and Ashley (2006) described WSUD in the following terms:

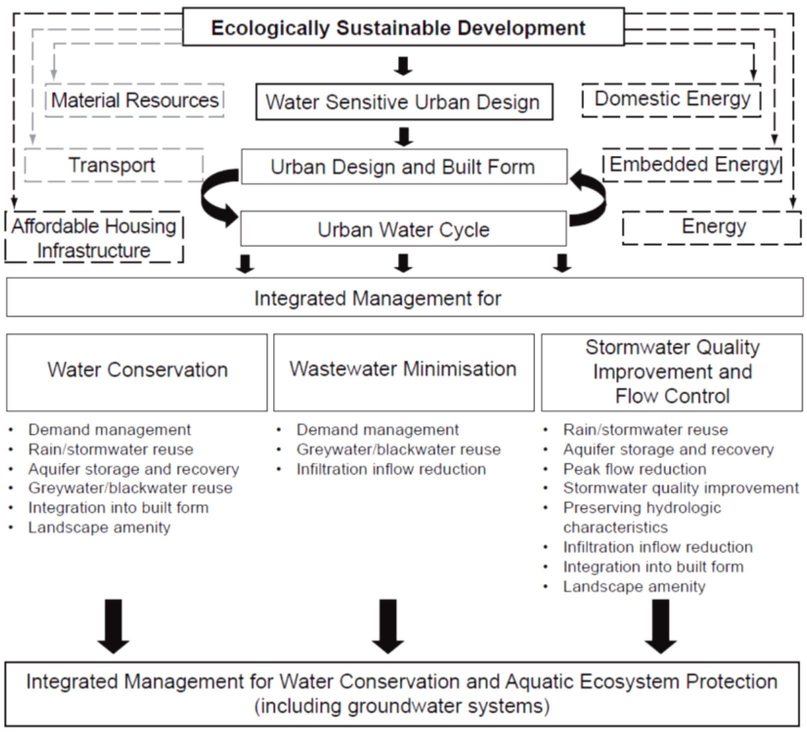
> WSUD….comprises two parts – 'Water Sensitive' and 'Urban Design'. Urban Design is a well recognised field associated with the planning and architectural design of urban environments, covering issues that have traditionally appeared outside of the water field but nevertheless interact or have implications to environmental effects on land and water. WSUD brings 'sensitivity to water' into urban design, i.e. it aims to ensure that water is given due prominence within the urban design processes.

> The words 'Water Sensitive' define a new paradigm in integrated urban water cycle management that integrates the various disciplines of engineering and environmental sciences associated with the provision of water services including the protection of aquatic environments in urban areas. Community values and aspirations of urban places necessarily govern urban design decisions and therefore water management practices. Collectively WSUD integrates the social and physical sciences.

This approach to WSUD suggested an ambition to interpret the term broadly, with water management being a strong factor in urban design and WSUD also incorporating a social dimension, where community values influence urban water management decisions.

Wong (2006a; 2006b) also advocated a broad interpretation of WSUD, claiming that WSUD can be used to deliver the urban water component of ecologically sustainable development. In his interpretation, he linked WSUD with water conservation, wastewater minimisation, and improved stormwater quality and flow regimes, and thus a reduction in the deleterious impacts of urban development on the water cycle:

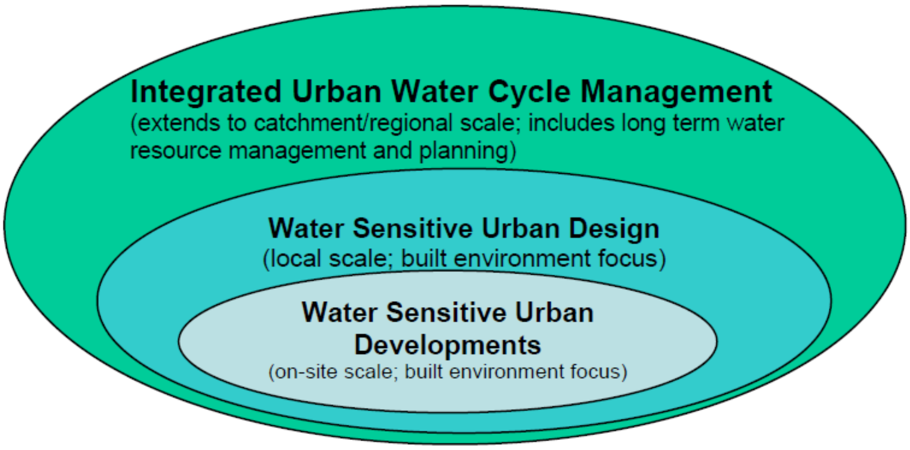
Figure 2-2: Proposed Links between WSUD and the Delivery of the Urban Water Component of Ecologically Sustainable Development



Source: Wong (2006b, 214)

A further approach to WSUD was set out in an Australian National Water Commission scoping paper (2007). This paper was intended to assist the implementation of Clause 92 of the *Intergovernmental Agreement on a National Water Initiative* and adopted the same definition of WSUD as the Intergovernmental Agreement. It also linked the concepts Integrated Urban Water Cycle Management, WSUD and Water Sensitive Urban Developments, which are referred to in Clause 92 of the Agreement, by applying them at different physical scales:

Figure 2-3: Relationship between Integrated Urban Water Cycle Management, Water Sensitive Urban Design and Water Sensitive Urban Developments



Source: Australia. National Water Commission (2007, 9)

In contrast, a 2009 Australian government publication (BMT WBM) specifically designed to foster the implementation of the WSUD commitments in the *Intergovernmental Agreement* defined WSUD without linking it with Integrated Urban Water Cycle Management and Water Sensitive Urban Developments. It stated (BMT WBM 2009, 1-3) that:

> In its broadest context, WSUD is the integrated design of the urban water cycle, incorporating water supply, wastewater, stormwater and groundwater management, urban design and environmental protection. It represents a fundamental shift in the way water and related environmental resources and water infrastructure are considered in the planning and design of cities and towns, at all scales and densities.

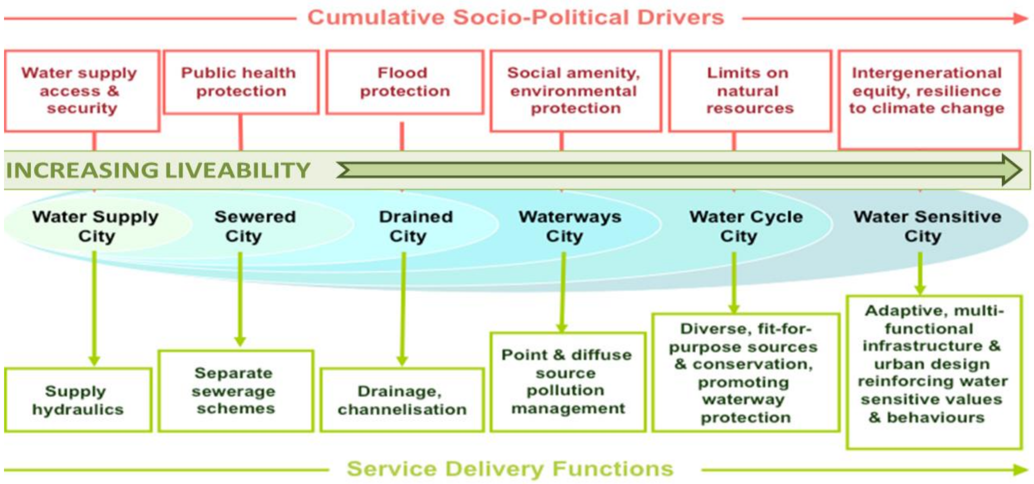
The concept in Figure 2-3 was also disputed by Delectic et al. (2013), who contested the idea that WSUD represents the local scale implementation of Integrated Urban Water Cycle Management principles. They stated (2013, 68) that 'integrated urban water cycle management (IUWM)…is a subset of WSUD…We can achieve IUWM with a concentrated centralised infrastructure, while the many additional benefits of WSUD can only be attained through a largely decentralised approach to urban water management'. This interpretation suggests that IUWM and WSUD are not distinguished by operating at different physical scales, but are differentiated by whether they rely on centralised (IUWM) or decentralised urban water infrastructure (WSUD).

The continuing debate about how best to interpret WSUD was noted by Lee and Yigitcanlar (2010). They considered that there was confusion about the meaning of WSUD, with some stakeholders perceiving WSUD as a stormwater management measure, and others seeing it as a fully integrated urban water management system. Lee and Yigitcanlar also argued that this continued debate was not benign, but represented a hindrance to the acceptance and implementation of WSUD.

A year later, Wong et al. (2011) noted the variable definitions of WSUD, and contrasted the definition in the *Intergovernmental Agreement on a National Water Initiative* with the broader approach of Wong and Ashley (2006). They did not attempt to resolve this ambiguity, but simply suggested that the varying definitions of WSUD adopted by practitioners reflect the wide range of uses of the WSUD framework.

Wong et al. (2011) also considered the links between WSUD and the 'water sensitive city' concept. The water sensitive city model describes an evolution from initial concerns with water supply, sewerage and drainage, through stages of greater attention to the environmental health of waterways and the water cycle, to the ultimate state of the water sensitive city. This water sensitive city is said to incorporate adaptive, multi-functional infrastructure, be resilient to climate change and provide intergenerational equity (Wong, Brown, and Deletic 2008; Wong and Brown 2009; Brown, Keath, and Wong 2009). Wong et al. (2011) argued that WSUD is an integrative 'process', which brings together multiple urban water management objectives, while water sensitive cities are the 'outcome'. This suggested link between WSUD as the process and water sensitive cities as the outcome was reiterated elsewhere (Wong et al. 2012). According to this interpretation, WSUD provides a mechanism for a city to move to the ultimate water sensitive city stage on the evolutionary trajectory shown below:

Figure 2-4: The Water Sensitive City Evolutionary Pathway



Source: Brown, Keath, and Wong (2009), 850

A differing view about the relationship between WSUD and water sensitive cities was put forward by Ferguson et al. (2012). They asserted that WSUD and integrated water management are mechanisms which 'deliver individually on the Waterways City and the Water Cycle City respectively' (Ferguson et al. 2012, 12) As shown in Figure 2-4, these stages precede the water sensitive city. According to Ferguson et al., moving along the urban water evolutionary pathway from the waterways city and water cycle city stages to the water sensitive city requires the adoption of further water sensitive values and behaviours, which provide the foundation of the water sensitive city (2012, 12).

Yet another interesting view about the WSUD concept was that of Gardiner (2006; 2007), who placed it in a broader urban design context than other commentators. According to Gardiner, the initial ideas of WSUD, such as those put forward by

Mouritz (1996), were influenced by 'New Urbanism'[11]. Based on an examination of WSUD literature, Gardiner argued that WSUD co-opts elements of New Urbanism, such as increasing the public realm at the expense of the private realm, with a concomitant focus on communal space; increasing housing density; and the encouragement of mixed developments incorporating commercial and residential use. Gardiner perceptively stated that (2007, 294):

> Implicit in the original presentation of WSUD was a thinly veiled critique of modern cities – the alienation of people from public spaces, the dehumanising separation of nature from culture, and the superiority of methods that promote sustainability through local scale strategies. These were linked in the form of pedestrian friendly, water and energy efficient and family oriented spaces, consistent with the New Urbanist ideals prevalent in Western Australia at that time

Gardiner also indicated that the application of WSUD in Australia was characterised by the adoption of stormwater management practices in public open space corridors, without the broader New Urbanism aspirations being realised. Gardiner provided a useful analysis, which linked WSUD with broader ideas of how urban spaces should be organised. Despite these insights, Gardiner's ideas received very little formal recognition.

Notwithstanding the discussions about the precise scope and interpretation of WSUD, government support for WSUD was enhanced in 2013, when the South Australian state government released a policy specifically related to WSUD (South Australia. Department of Environment Water and Natural Resources. 2013). This was the first time this had been done by any Australian jurisdiction. The policy defined WSUD as (2013, 5):

> an approach to urban planning and design that integrates the management of the total water cycle into the land use and development process

This policy also linked Integrated Urban Water Cycle Management and WSUD in the same way as the 2007 Australian National Water Commission scoping paper.

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[11] According to Talen, the cornerstone of New Urbanism is building a sense of community, principally by integrating private residential space with adjoining public space, and by appropriate design and location of public space (1999, 1363). Useful reviews of New Urbanism are provided by Ellis (2002) and Grant (2006). The application of New Urbanism to residential developments in Perth is discussed by Falconer, Newman and Giles-Corti (2010).

At this point, it is time to review the development of the WSUD concept, to examine what meaning, or meanings, can be attributed to WSUD.

Review of Interpretations of the WSUD Concept

The preceding chronology of the development of WSUD indicates that no generally agreed definition of WSUD has been reached to date. Perhaps this is not surprising, given the many dimensions deemed to be important by different commentators. The diverse conceptions of WSUD resemble the differing interpretations of sustainable development by commentators with a wide range of perspectives noted by Sneddon, Howarth, and Norgaard (2006).

A comparison of the varied definitions of WSUD that have been suggested reveals crucial issues that have attracted different views, including:

1. Does WSUD relate to the entire urban water cycle, or is it mainly an urban stormwater management measure?
2. Are WSUD and Integrated Urban Water Cycle Management distinguished by operating at different physical scales, or by relying on decentralised and centralised infrastructure, respectively?
3. What is the relationship between WSUD and water sensitive cities?

This section examined the inception of the WSUD concept, its subsequent recognition in Australia and varied interpretations of the concept. The following section discusses how WSUD was defined, for the purposes of the research reported in this thesis.

2.5 Definition of WSUD Adopted in this Thesis

As discussed in section 2.4, a number of definitions of WSUD have been suggested. Table 2.3, which follows, includes an analysis of a number of the suggested definitions of WSUD from section 2.4. The definitions in Table 2.3 were suggested by influential actors and represent several primary approaches to formulating WSUD. The analysis in Table 2.3 is informed by the explicit, strong nexus between urban design and urban water cycle management that the discussion in section 2.4 showed is fundamental to the WSUD concept (Whelans, Maunsell

Halpern Glick and Thompson Palmer 1994; Mouritz 1996; Wong and Ashley 2006; Wong 2006a; Wong 2006b).

Table 2-3: Analysis of Primary Definitions of WSUD

Source	Definition	Discussion
Intergovernmental Agreement on a National Water Initiative (Council of Australian Governments 2004)	The integration of urban planning with the management, protection and conservation of the urban water cycle, that ensures urban water management is sensitive to natural hydrological and ecological processes	This definition explicitly links urban planning with urban water cycle management. However, the intended meaning of the term '…is sensitive to…' in this context is open to interpretation.
Wong and Ashley (2006)	WSUD…comprises two parts – 'Water Sensitive' and 'Urban Design'. Urban Design is a well recognised field associated with the planning and architectural design of urban environments, covering issues that have traditionally appeared outside of the water field but nevertheless interact or have implications to environmental effects on land and water. WSUD brings 'sensitivity to water' into urban design, i.e. it aims to ensure that water is given due prominence within the urban design processes. The words 'Water Sensitive' define a new paradigm in integrated urban water cycle management that integrates the various disciplines of engineering and environmental sciences associated with the provision of water services including the protection of aquatic environments in urban areas. Community values and aspirations of urban places necessarily govern urban design decisions and therefore water management practices. Collectively WSUD integrates the social and physical sciences.	This is a comprehensive definition, which indicates that the urban water cycle should influence urban design. It also includes a social dimension, whereby community values influence decision making. However, the definition is lengthy and unwieldy, to a degree that would detract from its ability to serve as an operational definition.
Joint Steering Committee for Water Sensitive Cities (2009)	In its broadest context, WSUD is the integrated design of the urban water cycle, incorporating water supply, wastewater, stormwater and groundwater management, urban design and environmental protection. It represents a fundamental shift in the way water and related environmental resources and water infrastructure are considered in the planning and design of cities and towns, at all scales and densities	This definition can be interpreted as subordinating urban design to urban water cycle management, instead of integrating these elements: 'WSUD is the integrated design of the urban water cycle, incorporating…urban design'
Government of South Australia (South Australia. Department of Environment Water and Natural Resources 2013)	an approach to urban planning and design that integrates the management of the total water cycle into the land use and development process	This definition emphasises the integration of urban design and the urban water cycle. It also suggests that the linkage between urban design and water cycle management should be given practical effect via the land development process. The definition is succinct.

Source: original table

Based on the analysis in Table 2.3, the South Australian government's definition (South Australia. Department of Environment Water and Natural Resources 2013) was adopted for the research described in this thesis. This definition explicitly points to the nexus between urban design and the urban water cycle, and is succinct.

2.6 Components of WSUD Practice[12]

The discussion earlier in this chapter showed that WSUD can be characterised as a concept, or idea. This concept is implemented via a range of WSUD 'practices'[13]. The research question in this thesis relates to how statutory land use planning influences these WSUD practices.

The following chapter, Chapter 3, will show that previous research about the influence of land use planning on the implementation of WSUD considered WSUD practice as an undifferentiated whole. In contrast with this approach, an analytical framework was developed for the current research by identifying a number of specific components of WSUD practice, which:

1. Are normative elements of WSUD practice
2. Are consistent with the definition of WSUD adopted for the research
3. Allow empirical investigation of the influence of statutory land use planning on WSUD practices, via the methods used in the research
4. Are independent of the specific urban water management measures used: while different urban developments may use different measures because of technical factors, comparisons between developments should still be possible
5. Provide new insights, compared with previous research.

Based on these considerations, and the insights into the WSUD concept gained from the discussion in section 2.4, the following components of WSUD practice were identified. The reasons for identifying each component are also shown.

[12] The components of WSUD practice identified in section 2.6 were initially reported as Williams (2016), which is Appendix 4 of this thesis.
[13] Practice in the Oxford Dictionary of English (2010) is defined as: 'The actual application or use of an idea, belief or method, as opposed to theories relating to it'. Practice is used in this sense, in this thesis.

Table 2-4: Components of WSUD Practice[14]

Component of WSUD practice	Objectives of Component	Rationale for Inclusion
Urban stormwater Management	Mitigate flood risks and adverse impacts on receiving environments by managing the quantity, quality and frequency of urban stormwater runoff.	Managing stormwater runoff is a core element of WSUD, however it is interpreted. Mitigating the adverse impacts of stormwater runoff is a fundamental part of WSUD practice. ***This component focuses on urban stormwater management***
Urban water cycle	Conserve urban water resources by managing and using them on a fit-for-purpose basis, to maximise the benefit they provide to the community.	This component reflects the broad intent of WSUD to protect the urban water cycle from the impacts of urban development, and links it with the protection and the conservation of natural resources, which are integral to the sustainability concept. ***This component focuses on the urban water cycle***
Urban water infrastructure	Enhance social and environmental benefits, and improve system resilience through combining centralised and decentralised urban water infrastructure systems.	A portfolio of centralised and decentralised infrastructure provides local social, environmental and amenity benefits, and enhances system resilience. ***This component focuses on urban water infrastructure***
Urban Design	Enhance social and environmental benefits, and improve system resilience by integrating urban water management with the urban design process.	WSUD explicitly links urban design and the urban water cycle. It follows that urban water management should be considered throughout the urban design process and should influence urban design outcomes. ***This component focuses on urban design***[15]

Source: original table

The identification of a set of discrete components of WSUD practice has some similarities with the approach used by Reynaers, in her investigation of how public private partnerships influence public values (2014). Reynaers 'operationized' the public values concept by identifying five specific values (accountability,

[14] A panel of urban water management and land use planning professionals from state and local governments, and private firms, was consulted during the development of the components of WSUD practice in Table 2.4. This consultation was designed to ensure that the components were defined in clear, unambiguous terms, which would support effective communications with practitioners during the empirical part of the research.

[15] Urban design 'is concerned with the arrangement, appearance and function of our suburbs, towns and cities. It is both a process and an outcome of creating localities in which people live, engage with each other, and the physical place around them' (Australia. Department of Infrastructure and Transport 2011). In the context of WSUD, urban design is identified with elements such as subdivision layout, streetscape layout and design, the configuration of roads, public open space design, and the design of the stormwater drainage system (Victoria. Stormwater Committee 1999, 47-62).

transparency, responsiveness, responsibility and quality) and then examined how these were influenced by public private partnerships, in four case studies.

The first component in Table 2-4 relates to urban stormwater management. As discussed earlier, in section 2.4, the effective management of urban stormwater is an integral part of all reported interpretations of WSUD and was a central part of the WSUD concept, as originally conceived (Mouritz 1996). Any urban development that claims to include WSUD practices must attempt to control the potentially deleterious impacts of stormwater. It follows that an empirical investigation of the implementation of WSUD practices, such as the current research, must consider how urban stormwater is managed.

The second component relates to the protection and management of urban water resources, and their use on a fit for purpose basis. This component indicates that, when WSUD is implemented, the complete urban water cycle should be managed effectively. This is consistent with the interpretation of WSUD advocated by the Water Sensitive Urban Design Research Group (1990), Mouritz, Evangelisti, and McArthur (2006), BMT WBM (2009) and South Australia. Department of Environment Water and Natural Resources (2013). It is also consistent with Wong's (2006a; 2006b) explicit linkage of WSUD with the management of the urban water cycle and, further, with the delivery of the urban water component of ecologically sustainable development, as shown earlier in Figure 2.2. By considering the management of urban water resources generally, this component is consistent with the definition of WSUD adopted for the research, which refers to: '…the management of the total water cycle…'. This component also refers to the use of urban water resources on a fit for purpose basis, an approach identified as part of the new IUWM paradigm discussed previously in section 2.3 (Pinkham 1999, 5-6; Mitchell, Mein, and McMahon 2002; Mitchell 2006, 590-591). In summary, this component of WSUD reflects the ability of the WSUD concept to consider the urban water cycle as a whole and the definition of WSUD adopted in this thesis.

The third component indicates that the implementation of WSUD should utilise a combination of centralised and decentralised urban water infrastructure. This is consistent with Mouritz's (1996) statement that initial ideas of WSUD included managing stormwater by localised storage and retention, instead of via large pipe networks, and complementing centralised systems with decentralised infrastructure, to enhance reuse and recycling opportunities. Wong (2006a; 2006b) and BMT WBM (2009) also state that the implementation of WSUD should include the use of decentralised infrastructure to manage stormwater, and to enhance reuse and recycling opportunities. Managing stormwater by decentralised infrastructure allows it to be captured, treated and infiltrated close to its source, which is essential if urban waterways are to be protected and restored (Walsh, Fletcher, and Ladson 2005; Potter and RossRakesh 2007; Burns et al. 2012; Vietz et al. 2014; Walsh et al. 2016). Decentralised infrastructure allows alternative water sources, such as treated stormwater and recycled water, to be used locally to irrigate urban landscapes, protect environmental values and improve urban amenity (Diaper, Tjandraatmadja, and Kenway 2007; Cook et al. 2009; Sharma et al. 2013). Improving urban amenity is consistent with the urban design aspirations of WSUD. Delectic et al. (2013) suggest that the use of decentralised infrastructure is an essential component of WSUD and argue that it distinguishes WSUD from IUWM, which can be delivered via centralised infrastructure. At a broader level, Pinkham (1999, 5-6) states that the use of diverse, decentralised infrastructure is a characteristic of the new urban water paradigm that emerged at the turn of the century, which, according to this thesis, was exemplified by the emergence of a series of new urban water models, including WSUD.

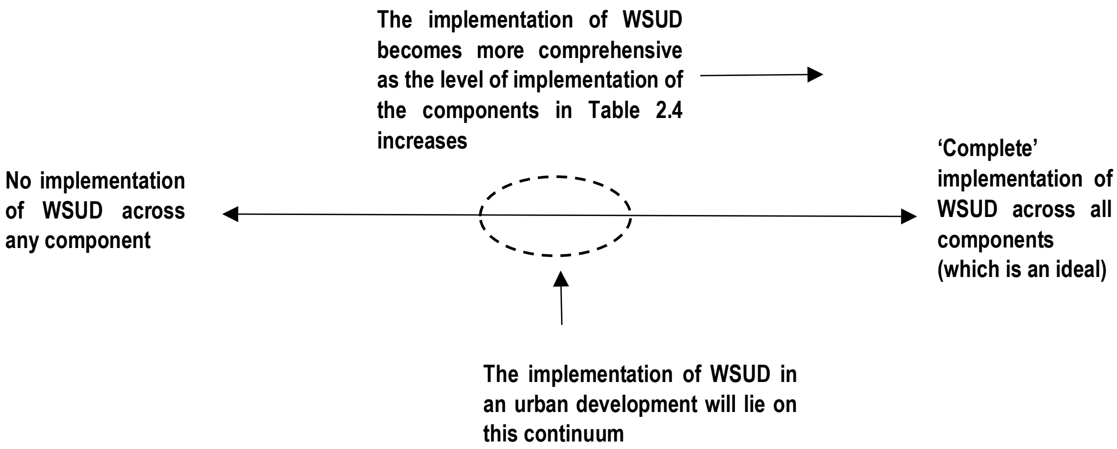
The fourth component indicates that urban water management should be considered during the urban design process and influence urban design outcomes. As was shown in section 2.4, the idea of integrating the urban water cycle and urban design is at the very heart of WSUD. As discussed by Hoyer et al. (2011), it is the alignment of water cycle management and urban design inherent in WSUD that distinguishes WSUD from other urban water management models. This component is also consistent with the definition of WSUD adopted for the research, which stresses the integration of urban water cycle management with urban planning and design.

There is likely to be overlap between these four components. For example, urban stormwater management does relate to the management of the urban water cycle as a whole[16]. Integrating urban water cycle management with urban design may also improve the management of stormwater runoff and increase opportunities to use decentralised infrastructure. However, such overlap does not negate the focus on an important element of WSUD practice that each component provides, or prevent the components being used for analytical purposes. Interpretation of the sustainable development concept provides a useful comparison: Sneddon, Howarth, and Norgaard (2006, 255-256) point out that the three-legged stool interpretation of sustainable development includes three elements (human well-being, equitable access to resources across and within societies, and the maintenance of ecological integrity) that interact in complex ways, but this has not prevented widespread use of the three-legged stool idea. Thus, a broad concept, such as WSUD, or sustainable development, can be analysed using a framework that includes a number of components, even if there is some overlap between them.

Having defined these four components of WSUD practice, it is acknowledged that the definitions in Table 2.4 include qualitative terms such as mitigate, maximise and influence. There is no objective scale associated with these terms. Clearly, judgement is required to assess the degree of implementation of the components on a continuum from no implementation at all to, ideally, complete implementation. The implementation of WSUD in a development becomes more comprehensive as the level of implementation of the components of WSUD practice identified above increases. Schematically:

[16] Strictly, stormwater management could be regarded as a subset of urban water cycle management. However, as was shown in section 2.4, stormwater management has played a key role in the development of the WSUD concept, to the extent that urban stormwater management has sometimes dominated the broader, whole of urban water cycle interpretation of WSUD. Given these circumstances, it is reasonable to identify distinct urban stormwater management and urban water cycle management components of WSUD practice, for analytical purposes.

Figure 2-5: Implementation of WSUD in a Development



Source: original figure

Collectively, these components relate to the implementation of WSUD practices associated with managing urban stormwater, managing the urban water cycle as an integrated whole, employing centralised and decentralised urban water infrastructure, and establishing a nexus between urban planning and the urban water cycle. The components provide a comprehensive and coherent framework to investigate the implementation of WSUD practices. They also provide a novel framework, which is more rigorous and precise than previous approaches, which considered WSUD practices as an undifferentiated whole.

It was noted earlier in this chapter that a number of innovative urban water servicing models, including WSUD, were developed around the turn of the century. The following section compares WSUD with these models. This places WSUD in the wider context of international efforts to reassess urban water management.

2.7 WSUD and other Urban Water Management Models

The development of a range of innovative urban water management models coincided with the emergence, late in the twentieth century, of what this chapter identified earlier as a new urban water paradigm. This section compares the concept of WSUD adopted in this thesis with a range of these models.

The development of a number of alternative urban water models should not be surprising, given the widely different climate regimes, levels of access to finance and technology, appetite for innovation and technical practices associated with the urban water sector across the globe. In Australia, New Zealand and much of the United States, two separate systems of pipes are used to collect, firstly, surface stormwater runoff and, secondly, domestic, industrial and commercial wastewater, whereas combined systems of pipes are used to convey both wastewater and stormwater runoff in much of Europe, and these different regimes affect urban water management practices (Brown 2005). According to Chocat et al. the diverse geographic circumstances in different countries greatly influence the environmental impacts associated with urban water management and have led to the creation of 'national urban water drainage schools of thought' (2001, 66).

To place WSUD in a broader international context, and to assist comparison, the following table (Table 2-5) summarises WSUD and a range of other urban water models, including low impact development[17], low impact urban design and development, total urban water cycle management, sustainable urban drainage systems and water sensitive planning. The literature about urban water management is extensive, growing and covers many regions (Fletcher et al. 2014). Therefore, the table includes urban water management models from a diverse range of locations across the globe.

[17] The term 'low impact development' appears to have first been used in 1977, in the context of land use planning, before coming into mainstream use in the 1990s to describe localised alternatives to previously accepted centralised urban stormwater systems (Fletcher et al. 2014).

Table 2-5: Comparison of a Range of Urban Water Management Models

	WSUD	Low Impact Development (LID)	Low Impact Urban Design and Development LIUDD)	Total Urban Water Cycle Management (The information in this column is derived from Lawrence et al. 1999)	Sustainable Urban Drainage Systems (SUDS)	Water Sensitive Planning
Country or region of origin	Australia	United States (United States Environment Protection Agency 2000)	New Zealand (van Roon 2005)	Australia	United Kingdom (Fletcher et al. 2014)	Israel (Carmon and Shamir 2010)
Period when the concept was initially developed	1990s	Mid 1990s (Prince Georges County. Department of Environmental Resources 1997; Prince Georges County. Department of Environmental Resources 1999)	Late 1990s (van Roon, 2005)	1990s	1990s (Butler and Parkinson 1997; Andoh and Iwugo 2002; Fletcher et al. 2014)	Mid 1990s (Carmon, Shamir, and Meiron-Pistiner 1997)
Does the concept focus on stormwater management, or does it consider the broader urban water cycle?	As discussed in section 2.4, some authors argue that WSUD concentrates on urban stormwater, while others state that it considers the overall urban water cycle.	Stormwater management	Urban water cycle as a whole	Urban water cycle as a whole	Stormwater management	The urban water cycle and, more generally, catchment management
Guiding principles of the concept	Integrate urban water cycle management with land use and development	'…a site design strategy for maintaining or replicating the predevelopment hydrologic regime through the use of design techniques to create a functionally equivalent hydrologic landscape' (United States Environment Protection Agency 2000; 1)	Mitigate the impact of urban development on the water cycle, to protect ecological and social values (van Roon 2005; van Roon 2011)	Use decentralised treatment measures to mitigate the effects of urbanisation on environmental values	'minimise the impacts from…development on the quantity and quality of the runoff, and maximise amenity and biodiversity opportunities…The philosophy of SuDS is to replicate, as closely as possible, the natural drainage from a site before development' (Woods-Ballard, et al. 2007, 1-1)	Water management is intrinsic to urban and regional planning and should be considered when planning commences. Consider hydro-geographic conditions at the start of any development project. Consider stormwater runoff as a resource, not a nuisance (Carmon and Shamir 2010)

Technical measures used to achieve the model's objectives	Manage stormwater by harvesting, detaining and treating rain and stormwater, to reduce peak flows and improve quality. Conserve potable water by measures such as demand management, and harvesting and reusing stormwater Minimise wastewater generation by demand management, and consider reuse of treated greywater and blackwater (Wong 2006b)	Control stormwater as close as possible to its sources, via small scale, distributed controls which are dispersed throughout the site (Prince Georges County. Department of Environmental Resources 1999). Hydrology is used as an integrating framework. Stormwater is managed as close as possible to the source by simple non-structural measures to create a multifunctional landscape. (Prince Georges County. Department of Environmental Resources 1999). Treatment measures typically include rain gardens, bioretention, rooftop gardens, swales, porous pavements, buffers and filter strips, disconnecting rooftop drainage and installing rainwater storage tanks (Huber et al. 2004) The term *Green Infrastructure* is also used in the United States to describe similar practices to LID (Hoyer, Dickhaut, Kronawitter and Weber 2011; Fletcher et al. 2014; 8)	Use a mix of measures to promote infiltration and evapotranspiration. Integrate land and water planning at the neighbourhood-to-catchment scale. Recycling may also be considered, when urban water supply, wastewater treatment and stormwater drainage systems can be integrated efficiently (van Roon 2005). Locate development at sites where assessments indicate that unacceptable impacts would be avoided and natural hydrological regimes would be maintained (van Roon et al. 2006).	Use small-scale, decentralised infrastructure to ameliorate the environmental impacts of urbanisation. Protect downstream areas against urban impacts. Integrate management of stormwater, groundwater, water supply and wastewater. Minimise demand by measures such as efficient water use, reducing water use for landscape irrigation, and changing industrial processes to reduce water use. Reuse water of suitable quality for non-potable water, on a fit for purpose basis.	Mitigate the impacts of stormwater runoff by moderating runoff rates, protecting water quality, integrating drainage systems with local environments, enhancing urban wildlife habitats and supporting natural groundwater recharge (National SUDS Working Group 2004; Woods-Ballard et al. 2007). Locate controls as close as possible to stormwater sources and provide treatment via sedimentation, filtration, adsorption and biological degradation. Controls should use a hierarchy based on prevention, source control, site control and regional control (National SUDS Working Group 2004; Woods-Ballard et al. 2007).	Consider hydro-geographic factors in the location of public open space and roads . Increase the density of urban development, to reduce runoff per housing unit and the area allocated to roads. Design land cover (i.e. pervious and impervious areas) to encourage infiltration or reuse of runoff. Use small, simple, low cost water treatment devices. Base regional-scale water planning on statutory catchment plans, which integrate human needs and the protection of ecological values (Carmon and Shamir 2010).

Source: Original table

Comparison of WSUD with other urban water management models

Table 2.5 demonstrates that there are parallels between WSUD and the other urban water management models summarised in the table. They all incorporate, to varying degrees, the characteristics of the new urban water paradigm identified by Pinkham (1999), as noted in Table 2.1 of this thesis. These characteristics include using decentralised, green infrastructure; allowing diverse technical measures; considering stormwater/wastewater to be a resource, and reusing treated water on a fit for purpose basis. This congruence between WSUD and other urban water management concepts is noted by Lloyd, who observes that: 'The emergence of WSUD in Australia is part of a wider movement at an international level towards the concept of integrated land and water management' (2001; 2). This view about the similarities between innovative urban water approaches such as low impact development and sustainable urban drainage systems is supported by Chocat et al. (2007), who refer to them collectively as the 'green scenario', suggesting they are not strongly differentiated. An analysis of terms related to integrated urban water management by Fletcher et al. similarly notes that 'The overlap in terms of specificity and breadth of application illustrates the extent of similarity of the underpinning ideas' (2014, 11). There is clearly a high degree of overlap between WSUD and the other urban water management schemes shown in Table 2.5.

That said, it is also clear that the urban water models in Table 2.5 differ in the scope of the urban water streams they consider. Some models focus on stormwater management (low impact development, sustainable urban drainage systems), while others consider the urban water cycle as a whole (total urban water cycle management, low impact urban design and development, water sensitive planning). This variation resembles the varied interpretations of WSUD's scope. During the initial development of WSUD, its main concern was stormwater management (Mouritz 1996) and, fifteen years later, Hoyer et al. (2011) continued to argue that WSUD mainly considers urban stormwater. This contrasts with Wong's view (2006a; 2006b) that WSUD applies to the urban water cycle as a whole and can be used to implement the urban water element of ecologically sustainable development. The lengthy debate about the urban water streams that are included, or not included, in the WSUD concept is mirrored in the varied scope of the models in Table 2.5.

However, stating that these urban water management models, including WSUD, significantly overlap is not stating that they are identical. WSUD places a strong emphasis on integrating water management with urban design, compared with other models. Evidence for this position is provided by Hoyer et al., who survey a range of approaches to stormwater management and state that 'Most decentralised stormwater solutions do not consider urban design in terms of contributing to the aesthetics and amenity of urban areas' (2011, 28). They also note that 'Past experiences with sustainable stormwater management in cities have made it clear that an integrative approach linking urban design demands must be formed. Water Sensitive Urban Design provides this link' (2011, 16). Wong and Ashley's description of WSUD (2006) explicitly refers to urban design and states that WSUD: 'aims to ensure water is given due prominence within the urban design processes'. WSUD strongly emphasises the nexus between urban water management and urban design and this is its most distinct contribution to efforts to establish new urban water management frameworks.

The use of the WSUD approach to improve urban water management has been advocated in a number of countries and regions, other than Australia, including South Africa (Fisher-Jeffes et al. 2012), the United Kingdom (Shaffer, Ashley, and Morgan 2012; Ashley et al. 2013), Denmark (Fryd et al. 2012) and the European Union (Hoyer et al. 2011). This multi-country advocacy for WSUD, with different climate regimes and cultural settings, supports the proposition that it is a useful urban water management concept.

2.8 Conclusions

This chapter started by considering the origins and subsequent evolution of the sustainable development concept and how sustainability became an objective of urban water management late in the twentieth century. The imperative to consider sustainability led to a reassessment of what had previously been viewed as successful conventional urban water practices. Coinciding with this reassessment, a number of new urban water management ideas emerged, typified by the inclusion of sustainability objectives, new technical practices and engaging a broader range of actors in decision making. These changes represented a paradigm shift compared with previous urban water management practices, based on large-scale centralised systems.

WSUD was one of these new ideas. It was conceived as a way to integrate urban planning and management of the urban water cycle, as described by Mouritz (1996). The subsequent debate about WSUD did not, however, result in a single, broadly accepted, interpretation emerging. Contested areas include the range of urban water streams that fall within the scope of WSUD, the link between WSUD and the water sensitive cities concept and the relationship between Integrated Urban Water Cycle Management and WSUD. A notable finding was that the debate about whether the WSUD is a concept that principally deals with stormwater management, or the urban water cycle as a whole, has continued during WSUD's lifetime, without being resolved.

A definition of WSUD was adopted for the research described in this thesis, which recognises the explicit link between urban design and urban water cycle management. Four components of WSUD practice were also identified, which provide an innovative framework to investigate influences on the implementation of WSUD. This approach permits closer analysis than previous investigations, which considered WSUD practices as an undifferentiated whole.

WSUD was compared with a range of other urban water management models. Similarities between these models were noted, consistent with their shared aim of integrating the principles of sustainable development with urban water management. That said, WSUD strongly emphasises the nexus between urban design and urban water management, as highlighted by Hoyer et al. (2011).

This chapter surveyed the origin and development of WSUD and considered how it compares with other urban water management ideas. The next chapter examines influences on the implementation of WSUD practices.

Chapter 3

INFLUENCES ON WSUD PRACTICES

3.1 Introduction

The previous chapter examined the development of the WSUD concept and placed it in the context of a new urban water paradigm. This chapter provides a more operational perspective, by considering factors that influence WSUD practices. It examines the literature and identifies shortcomings in previous research, which will be addressed in this thesis.

In order to understand the physical setting for WSUD in Australia, Section 3.2 briefly examines research about the current implementation of WSUD in Australian urban landscapes. It also notes that this research provides an incomplete understanding about the adoption of these practices. Section 3.3 examines literature about influences on the adoption of WSUD practices. Varied influences identified by different authors are compared, but it is also noted that definitive conclusions are hindered by differing interpretations of WSUD. This section also reviews previous research about how land use planning affects the implementation of specific WSUD practices and notes gaps in the strength of this research. This section concludes by noting that research about specific influences on WSUD practices has been complemented by investigations about the nexus between the broader socio-political environment and WSUD.

The planning regulatory framework for WSUD in Australian jurisdictions is also examined (section 3.4), identifying marked differences between them. Statutory land use planning is also defined in this section.

The last section in this chapter (section 3.5) summarises the literature review and shows how the current study complements previous research.

3.2 WSUD Practice in Australia

This section briefly considers the timing, location and extent of WSUD measures being adopted in Australian cities.

Gardiner and Hardy suggest (2005) that the implementation of WSUD in Australia occurred in three distinct phases:

Table 3-1: Proposed Phases in the Implementation of WSUD in Australian Cities

Phase	Typical Developments	Agents	Funding	Examples
Investigational	Display houses or small "villages"	Academic engineers in conjunction with state bodies and other partners	Subsidized by federal or state schemes and research projects	Healthy Home, Gold Coast, Figtree Place, The Sustainable House,
Demonstration	Infill developments such as car parks, town houses, specialist developments (eg Homebush Bay)	Academic Research Centres in conjunction with state departments	State and city level schemes subsidizing eventual commercial sales	Kogarah Town Square, Doncaster Park and Ride, New Brompton Estate
Application	Greenfield developments in environmentally sensitive locations or as required by state or local authorities	Developers, often using specialist consultants to design the stormwater system	Commercial: lot sales only	Mawson Lakes, Adelaide Carindale Pines, Brisbane, Lynbrook Estate, Melbourne

Source: Gardiner and Hardy 2005, 17

According to this analysis, WSUD implementation in Australia has moved beyond subsidised investigation and demonstration phases, to WSUD being adopted in new, multi-stage, commercially funded housing developments. Early examples of such commercial developments included the Lynbrook project in south-east Melbourne, Victoria, which was designed in 1999 and constructed in 2000 (Lloyd, Wong, and Chesterfield 2002; Lloyd, Wong, and Porter 2002), and Mawson Lakes, Adelaide, South Australia, constructed at the same time (Lloyd 2001, 14-15). The timing of developments such as Lyndhurst and Mawson Lakes indicates that the adoption of WSUD practices in new urban developments in Australian cities commenced around 2000.

After the early investigation and demonstration phases, less attention appears to have been paid to incorporating WSUD measures in existing urban areas. Gardiner (2007, 101) states that the adoption of WSUD has focused on new developments at the urban fringe. Weber, Stewart, and Dahlenburg (2009) note what they describe as increasing adoption of WSUD in new urban developments, but point to a lack of guidance about retrofitting WSUD controls to existing developments. As a result, they foresee the adverse environmental effects caused by untreated stormwater runoff from existing areas continuing. Segaran, Lewis, and Ostendorf (2014) share this concern and consider that spatial and economic constraints inhibit the adoption of WSUD measures in existing urban areas. Tjandraatmadja et al. (2014) indicate that, in the South Australian capital of Adelaide, the implementation of WSUD has been more extensive in new growth areas than in established urban areas. On the basis of these findings, it appears that, after early initiatives, the inclusion of WSUD measures in existing urban areas has been limited.

A further issue is the extent to which WSUD measures have been incorporated in residential areas, compared with other areas, such as industrial, commercial and institutional zones. Reviews of WSUD projects include a very large proportion of residential developments (Fletcher et al. 2004; Barton and Argue 2007; BMT WBM 2009; Sharma et al. 2012). However, it is unclear whether this reflects WSUD being implemented more extensively in residential areas than in land with other uses, or is due to purposeful selection of residential cases. Most of the WSUD schemes identified in a survey of WSUD practices in South Australia are located in residential areas, compared with a small portion in industrial and commercial areas (Myers et al. 2013). The limited information from the South Australian survey and the above-mentioned reviews suggest that the implementation of WSUD may have been more extensive in residential developments, compared with land uses such as industrial and commercial, but this is a tentative conclusion.

A limitation of the literature described above is that it does not clarify the extent to which WSUD practices have been implemented on a broad scale, such as across an entire city. Statements about the uptake of WSUD practices largely rely on descriptive terms and are not supported by quantitative information about the implementation of WSUD measures. Reviews of WSUD projects in Australian cities (Fletcher et al 2004; Barton and Argue 2007; BMT WBM 2009; Sharma et al. 2012) focus on specific developments and do not consider how extensively WSUD practices have been implemented at the city-wide scale. One exception here is the quantitative data of Tjandraatmadja et al. (2014). This study included an inventory in South Australia, which identified 220 sites where WSUD practices had been adopted, heavily concentrated in Adelaide. Given that the population of the state at that time was 1.69 million and that of Adelaide 1.30 million (Australia. Australian Bureau of Statistics 2016), this comparatively limited number of sites suggests that WSUD had not been comprehensively adopted in South Australia, at that time. A useful perspective is provided by Werbeloff, who suggests that WSUD 'remains somewhere between a fringe and mainstream practice…there is still some way to go before the practice is fully embedded within the urban water system of Australian cities' (2013, 129). Again, however, Werbeloff does not provide evidence to substantiate this claim. Thus, a precise understanding about the extent of WSUD implementation in Australian cities remains elusive.

In general terms though, we might conclude that, following initial investigation and demonstration phases, significant adoption of WSUD practices in new urban developments commenced in the early 2000s. While the evidence is sparse, it also seems likely that the inclusion of WSUD controls in existing urban areas has not been extensive. Overall then, the WSUD notion is not a fringe idea and WSUD practices have been adopted, to some extent, in Australian cities for more than a decade.

3.3 Influences on WSUD Practices

This section reviews the literature about factors that have been reported to affect the implementation of WSUD. Literature about a range of managerial, technical and institutional issues, and the specific role of land use planning, is described in 3.3.1 and 3.3.2, respectively. An assessment of this literature is provided in 3.3.3. As scholarly investigations continued, they considered the broader social, cultural and political environment. This work, outlined in 3.3.4, represents an important increase in the scope of research about WSUD practice.

3.3.1 Literature about Factors that Influence WSUD Practices

The examination of factors potentially influencing the implementation of WSUD practices commenced soon after the concept was first put forward, as evidenced by the studies of Campbell (1994), Wong and Eadie (2000) and Lloyd (2001).

Campbell describes proposed measures to promote the implementation of WSUD, including building partnerships between state and local governments, recognising WSUD principles in local government contracting and maintenance processes, and preparing catchment management plans (1994, 192). He also recommends ‘incorporating WSUD concepts into town planning schemes, and subdivisional[18] and development conditions’ (1994, 192). Wong and Eadie (2000) argue that WSUD could be promoted by improved technical practices, better community engagement, using collaborative, multi-disciplinary design teams, and by state and local governments making the adoption of WSUD ‘a condition of development by making the necessary amendments to their regulatory planning instruments and relevant urban planning and design guidelines’ (2000, 1287). Campbell, and Wong and Eadie, are consistent in suggesting the use of land use planning regulation to promote the adoption of WSUD. However, these authors do not include explicit evidence from reviews of WSUD practice or case studies to support their recommendations. This absence suggests that the robustness of their conclusions is likely to be limited.

A range of influences, including regulation, is also suggested by Lloyd (2001). She outlines ways to encourage the adoption of WSUD practices, as identified at a conference, held in 2000, of stakeholders from local and state government, consultants and the research sector. Lloyd groups these influences under four headings:

1. Regulatory framework
2. Assessment and costing
3. Technology and design
4. Marketing and acceptance.

The conference participants suggested a number of regulatory initiatives, including less prescriptive regulation, stronger collaboration between state and local governments to create an effective operating environment for WSUD, and the amendment of policies, codes and guidelines to reflect WSUD principles. When considering Lloyd’s report, some limitations should be noted. The conclusions are drawn from a stakeholder workshop, and the evidence and arguments used to reach them are not explicitly identified. Also, the ‘effective

[18] In the Australian context, subdivision of land refers to dividing a parcel of land into smaller lots, which can be dealt with separately. For example, the *Subdivision Act 1988* (Vic) defines subdivision as ‘the division of land into two or more parts which can be disposed of separately’ (s 3(1)).

operating environment' for WSUD sought from collaboration between state and local governments is not described, preventing rigorous assessment of this idea.

Lloyd, Wong, and Chesterfield (2002) describe the results of a survey of stormwater managers in Perth, Western Australia, who considered potential hindrances to WSUD practices. Interestingly, this group considered that, for that jurisdiction at least, 'An effective regulatory and operating environment does not exist at the State or local government level' and that this was the most significant obstacle to WSUD implementation (2002, 25). Lloyd, Wong, and Chesterfield conclude that: 'The most significant constraint to adoption appears to be the lack of an appropriate planning and regulatory framework' (2002, 31). This reflects what they consider to be the lack of progress, to that point, in the development of integrated planning frameworks to support WSUD. In their view, such a framework should:

1. Set state-wide environmental objectives for stormwater management
2. Incorporate those objectives into state planning policy
3. Provide model provisions to incorporate the objectives into local government planning schemes
4. Develop appropriate assessment tools.

According to them, this framework would clarify the role of the planning regulatory regime in enabling WSUD practices. However, Lloyd, Wong, and Chesterfield base their conclusions on a survey of stakeholders from a single location about stormwater management only, making it unwise to draw conclusions about WSUD practices more generally from their study.

The potential effects of the regulatory framework are also considered by Taylor and Wong (2002a; 2002b; 2002c) and Taylor and Weber (2004). Taylor and Wong (2002a; 2002b; 2002c) consider the urban stormwater component of WSUD and examine the ability of what they term 'non-structural measures' to improve urban stormwater quality. Using evidence from reports and a survey of stormwater managers from the United States, New Zealand and Australia, Taylor and Wong report that the most important non-structural measure is the adoption of appropriate town planning controls. These controls include recognising WSUD in town planning schemes and addressing WSUD in development applications and approvals. Taylor and Weber (2004) also support the capacity of regulatory frameworks to facilitate WSUD, but they argue that regulation has to operate within a broader policy framework, which 'refers to a clearly defined and widely endorsed set of WSUD related objectives which are given effect through instruments such as mandatory town planning controls' (2004, 593). They argue that planning controls are central to achieving WSUD outcomes and these controls should include quantitative, measurable targets. Taylor and Weber derive their conclusions from a discussion of what they believe to be general principles for regulatory design. In summary, Taylor and Wong (2002a; 2002b; 2002c) and Taylor and Weber (2004) suggest that appropriate land use planning regulation has the ability to encourage the adoption of WSUD practices.

Another perspective on the ability of regulatory frameworks to influence WSUD outcomes is provided by Gardiner and Hardy (2005), and Chandler and Eadie (2006), based on stakeholder surveys. These authors indicate that, according to the stakeholders, fragmented and unsupportive regulatory environments are notable impediments to the implementation of WSUD.

Gardiner and Hardy (2005) describe a survey of WSUD stakeholders in Australia, which suggested that hindrances to WSUD implementation, which had been described several years earlier, were still present at the time of the survey. The survey indicated that, for the participating stakeholder group, the regulatory impediments to WSUD described by Lloyd (2001) were largely unchanged. The stakeholders also reported that planning frameworks with a long-term sustainability focus facilitated WSUD, as did the existence of regional catchment scale water quality planning. Planning at the city or catchment scale is also advocated by Taylor and Wong (2002b). According to Gardiner and Hardy's survey, regulatory obstacles were a much more severe hindrance to the implementation of WSUD than gaps in technical knowledge. However, this conclusion may have simply reflected the background of the survey respondents, thirteen of the seventeen of whom were from the development industry.

Chandler and Eadie (2006) discuss the implementation of WSUD in South-East Queensland. A key impediment to WSUD, identified by interviews and workshops with WSUD stakeholders from the public and private sectors, is what is described as a poorly articulated, overly complex regulatory regime. The development of a better-articulated framework, including policy and regulatory measures and quantitative targets for specific pollutants, is recommended to address these perceived shortcomings. Fletcher, Delectic, and Hatt (2004) also call for a more consistent, coherent regulatory and policy framework to encourage the uptake of WSUD practices.

Wong (2006a) reviews the adoption of WSUD practices in Australia. He identifies four key elements said to influence the implementation of WSUD in Australia: the regulatory framework; assessment and costing; community acceptance and governance; and technology and design. These elements largely resemble those previously identified by Lloyd (2001). Under the community acceptance and governance heading, Wong identifies an increased role for local communities in fostering WSUD by mechanisms such as identifying local urban water management problems, participating in the development of WSUD strategies and taking part in workshops to identify sustainable water futures and develop local WSUD plans. The capacity for community engagement to encourage the adoption of WSUD measures is also highlighted by Donofrio et al. (2009), based on experience in the United States.

At this point, it is worth noting that the literature discussed above commonly includes the land use planning regulatory framework among the factors identified as influencing the implementation of WSUD. Notably, the influence of this framework is described as potentially favourable, in the case of well-designed frameworks, which include appropriate requirements (Campbell 1994; Wong and Eadie 2000; Taylor and Wong 2002a; Taylor and Wong 2002b; Taylor and Wong 2002c; Taylor and Webber 2004). Equally, it is reported to be potentially unfavourable, in the case of poorly articulated frameworks, or frameworks lacking explicit requirements related to the implementation of WSUD practices (Lloyd

2001; Lloyd, Wong, and Chesterfield 2002; Gardiner and Hardy 2005; Chandler and Eadie 2006).

Major studies by Roy et al. (2008) and Sharma et al. (2012) provide further insights into influences on WSUD practice. Both these studies sought to identify impediments, and actions to address them, from a range of evidence. They provide insights into perceived obstacles to the implementation of WSUD and potential solutions, some two decades after the concept was articulated.

Roy et al. (2008) examine possible impediments to watershed scale implementation of WSUD in the United States and Australia, via a literature review and the experiences of the authors and their colleagues. They interpret WSUD as sustainable urban stormwater management, and use the term 'watershed' to refer to drainage units of varying physical scale, which may include one or multiple jurisdictions. Roy et al. report seven groups of impediments. These groupings and proposed actions to address them are as follows:

Table 3-2: Reported Impediments to Sustainable Stormwater Management and Potential Solutions

Impediment	Proposed solution
Uncertainties in performance and cost	Conduct research on costs and watershed-scale performance.
Insufficient engineering standards and guidelines	Create a model ordinance and promote guidance documents.
Fragmented responsibilities	Integrate management across levels of government and the water cycle.
Lack of Institutional Capacity	Develop targeted workshops to educate professionals.
Lack of Legislative Mandate	Use grassroots efforts to garner support for ordinances and regulations.
Lack of sufficient finding and effective market incentives	Address hurdles in market approaches to provide funding mechanisms.
Resistance to change	Educate and engage the community through demonstrations.

Source: adapted from Roy et al. (2008)

Roy et al. also comment on the factors they believe are associated with successful regional-scale stormwater management programs in the US and Australia. They state that a requirement to address significant water quality impacts on receiving waters is an important aspect of these successful programs (2008, 354). This is consistent with the findings of and Gardiner and Hardy (2005), and Taylor and

Wong (2006b). Both these studies point to water quality planning at the regional or catchment scale being an impetus for WSUD.

Roy et al. base their conclusions on comparing experiences in the United States and Australia, which supports the robustness of their findings. They also highlight the importance of applying WSUD measures across an entire watershed, because aquatic ecosystems can be degraded significantly by untreated stormwater runoff from a small part of a catchment. Roy et al. compare practices at the national scale, so their discussion of impediments and solutions is very general and does not include specific reform proposals. From a regulatory perspective, a lack of legislative mandate is identified as an impediment, but the proposed solution is limited to generating political support for legislative change via grassroots activism (Roy et al. 2008, 356).

A more recent study by Sharma et al. (2012) examines impediments and constraints to the uptake of 'water sensitive urban developments' in Australia. They define these as developments designed in accordance with Integrated Urban Water Management principles and incorporating WSUD measures, to enhance the sustainability of urban water services. The scope of some of the developments that Sharma et al. consider extends beyond the definition of WSUD in this thesis and includes the use of recycled wastewater in what are otherwise conventional urban settings. However, their investigation was extensive and included multiple sources of information (literature survey, desktop analysis, site visits and surveys), so it provides useful insights. Sharma et al. (2012) identify eight main groups of impediments. These are tabulated below, along with the proposed responses of Sharma et al.:

Table 3-3: Reported Impediments to Water Sensitive Urban Developments

IMPEDIMENT/CONSTRAINTS	PROPOSED RESPONSE
Governance, regulations and guidelines Governance frameworks fail to recognise externalities and the range of objectives associated with sustainable urban water management. Policies and guidelines are not consistent across jurisdictions and levels of government.	Improve coordination between levels of government, jurisdictions and industry. Develop consistent policies and guidance, which still provide flexibility to consider site-specific conditions.
Community acceptance and social impacts The community need a better understanding of decentralised systems. Non-potable sources may be used inappropriately.	Continuous engagement with residents during a project's lifetime, including the provision of information. Consult with local government, water service providers and regulators at the planning and design stages.
Skills and knowledge Water sensitive urban development is a departure from conventional practices and challenges professionals and organisations.	Build capacity of all levels of government and industry sectors. Training institutions and professional bodies should adopt WSUD in their curricula and training.
Public health Community concerns about perceived health and safety risks. Potential for cross-connections between potable and recycled water supplies.	Develop national standards to validate WSUD measures, including long-term monitoring. Educate professionals and the community about WSUD technology.
System evaluation, performance and monitoring Limited information about the performance of WSUD, particularly new techniques. Need guidance for small scale operators about system selection, evaluation and monitoring.	Obtain and disseminate better information about system performance. Use technical data to revise and expand WSUD guidance. Develop consistent system evaluation methods.
Financial incentives for WSUD Lack of recognition of the externality benefits of water sensitive urban developments in financial instruments, such as fees at the development stage, and water and sewerage charges.	Develop policies and regulations which recognise the externality benefits associated with water sensitive urban developments, compared with conventional development.
System operation and maintenance Lack of familiarity with operation and maintenance (O &M) requirements. Lack of data about long-term performance.	Develop O & M best practices and include them in guidelines. Clearly define O & M responsibilities.
Sustainability and broader system impacts Difficult to account for the externalities associated with different urban water servicing options, including WSUD.	Study the impacts of water sensitive urban developments outside development boundaries. Develop economic models that properly account for externalities and adopt them in guidance and regulation.

Source: adapted from Sharma et al. (2012)

Sharma et al. suggest a number of regulatory measures to foster WSUD, such as better harmonisation of policies and guidance within and between jurisdictions, the involvement of regulators at the planning and design stages of projects and improved recognition of externalities. They also state that: 'A current knowledge gap identified is the lack of research on the relationship between urban water and land use planning' (2012, 344). This is consistent with there being a lack of knowledge about how land use planning actually influences the implementation of specific WSUD practices.

More recently again, Tjandraatmadja et al. (2014) reviewed impediments to the adoption of WSUD in South Australia. Their study used evidence from an inventory of sites incorporating WSUD practices, an assessment of the regulatory framework, surveys, interviews and community consultation. Tjandraatmadja et al. state that WSUD implementation has been limited in South Australia, compared with other Australia jurisdictions, such as Queensland and Victoria, where they believe that 'the proliferation of WSUD has been strongly driven by State water quality targets…developed on the basis of detailed monitoring studies that linked the health of receiving waters with runoff quality' (2014, 75). Tjandraatmadja et al. identify impediments and potential responses, as follows:

Table 3-4: Impediments to the Adoption of WSUD in South Australia and Proposed Responses

IMPEDIMENTS	PROPOSED RESPONSE
Need for improved capacity for WSUD adoption The ability to promote WSUD practices varies within, and between, local governments. The technical knowledge needed to design, install and maintain WSUD infrastructure varies widely.	Enhance local government capacity to implement WSUD. This should include the ability to link local decisions about WSUD to wider catchment scale planning.
Fragmented approach to WSUD implementation Local government plays a critical role in the implementation of WSUD, but the lack of a coherent state level policy framework means that different local governments can have different policies, capacities and priorities related to WSUD.	Establish a state-wide policy and institutional framework for WSUD. Clarify roles and responsibilities related to the implementation of WSUD.
Knowledge gaps There is a lack of reliable information about the performance, externalities and operating and maintenance requirements of WSUD assets in the South Australian context.	Monitor the performance of WSUD systems that have been installed in South Australia, to improve knowledge about these aspects in South Australia. Build knowledge about how small-scale distributed systems contribute to meeting catchment objectives.
Perceptions of risk and costs There is uncertainty in risks (public health and environmental) and costs associated with WSUD assets.	The improved knowledge about the performance of WSUD systems in South Australia should help to address this impediment.
Poor policy coordination and lack of mechanisms to implement WSUD targets There is a lack of state legislation requiring WSUD targets to be adopted in planning approvals. Coordination between state government agencies is inadequate.	Develop state-level targets and policies to support the implementation of WSUD. Include WSUD requirements in the development approval process.
Inadequate community understanding and acceptance Many residents do not understand the benefits provided by WSUD, reducing their willingness to pay for them.	Provide residents with information about the function, operation and benefits of WSUD.

Source: adapted from Tjandraatmadja et al. (2014)

Tjandraatmadja et al. recommend that objectives related to WSUD be included in the land use planning regulatory system (2014, 80). Tjandraatmadja et al. also suggest that targets be developed to encourage the implementation of WSUD, while noting that stakeholders prefer performance-based targets, instead of prescribed actions (2014, 81).

Having surveyed a number of investigations of factors claimed to influence the adoption of WSUD practices, it would be useful to summarise and classify the influences they identify. Table 3.5, which follows, does this. It identifies findings and recommendations about factors said to influence the adoption of WSUD practices, and groups these under a number of themes. These themes are:

1. Regulatory framework
2. Planning, design and maintenance of WSUD infrastructure
3. Financing WSUD
4. Acceptance of WSUD
5. Partnerships and capacity building
6. Other factors.

Table 3-5: Findings and Recommendations about Factors Reported to Influence the Adoption of WSUD Practices

Type of influence	Campbell 1994	Wong and Eadie 2000	Lloyd 2001	Lloyd, Wong, and Chesterfield 2002	Taylor and Wong 2002a; 2002b; 2002c	Taylor and Weber 2004	Gardiner and Hardy 2005	Chandler and Eadie 2006	Wong 2006a	Roy et al. 2008	Sharma et al. 2012	Tjandraatmadja et al. 2014
Regulatory framework	Include WSUD concepts in town planning schemes and development approval/subdivision conditions.	The planning approval process and supporting guidance should require the implementation of WSUD.	Include WSUD objectives in the regulatory regime for urban developments. Require developers to show how they would meet these objectives. Develop and implement local development standards to protect the urban water cycle and mandate them via regulation.	Specify statewide environmental objectives for stormwater management. Incorporate objectives into state planning policy. Provide model provisions to incorporate objectives into local government planning schemes. Develop appropriate assessment tools.	Key tools to manage urban stormwater include: • land use planning controls applied via planning schemes and development approvals • city or catchment scale urban stormwater plans • enforcement processes (licensing/ auditing/ penalties).	Facilitate WSUD by developing policy frameworks that include explicit objectives, which are implemented by appropriate regulatory instruments. Include quantitative, measurable targets in planning controls. Provide technical standards, models and guidance to support planning controls.	Inappropriate regulation is a more significant obstacle than technical factors. Claimed regulatory failings include inflexibility and undue complexity. WSUD is facilitated by master planning and regional-scale water quality planning.	Overly complex regulatory regimes should be addressed by developing frameworks that include coherent policies and regulations, and set quantitative targets.	Fragmented roles and responsibilities impede integrated water cycle management. Practical, equitable performance standards would support the implementation of WSUD practices.	The current lack of a clear legislative WSUD mandate should be addressed by encouraging community support for more explicit regulation.	Address Inconsistent regulations and guidelines by improving coordination between governments and industry, and preparing consistent policies and guidance, which provide flexibility to consider site-specific conditions.	A state-wide policy and institutional framework to support WSUD should be established. Develop transparent and efficient processes to include WSUD objectives in the land use planning and approvals system. Develop performance-based targets related to the implementation of WSUD.
Planning, design and maintenance of WSUD infrastructure	Incorporate WSUD principles and practices in the design, construction and maintenance regimes of local government stormwater systems. Prepare catchment-scale plans to prioritise actions. Deal with water quality problems at their source, in accordance with integrated catchment management principles.	Collaborative design teams should be used to plan and design WSUD infrastructure, using a multi-disciplinary approach.	Use multi-disciplinary teams to select and design WSUD schemes. Ensure than an appropriate post-installation regime to manage WSUD infrastructure is implemented. Ensure information about WSUD is transferred from the research sector to industry and government.		City-wide maintenance processes have a high potential to improve stormwater quality.			There are gaps in technology and design, particularly a lack of guidance about site-specific design factors and information about long-term performance of WSUD assets.	WSUD elements should be integrated with the planning and design of urban areas at a range of physical scales. There are emerging opportunities to integrate WSUD at the building scale.	Engineering standards and guidelines are insufficient.	Improve knowledge about system evaluation, performance and monitoring. Develop best practices for system operation and maintenance (O & M) and define O & M responsibilities.	The adoption of WSUD in South Australia is inhibited by a lack of knowledge about the performance and costs of WSUD systems in the local context.

Financing WSUD		Encourage the community to manage WSUD assets, to reduce reliance on funding from state and local governments.	Quantify externalities and include them in financial analyses Incorporate off-the-shelf components in WSUD infrastructure, to minimise lifecycle costs.				WSUD is seen as more costly than conventional development, partly due to the time and cost needed to gain approvals.	Local government and the private sector are concerned about perceived costs associated with WSUD. There is a lack of incentives to adopt WSUD.	WSUD can be advanced by identifying lifecycle costs, including externalities. Better cost information is becoming available from monitoring of WSUD elements.	There are uncertainties about the performance and cost of WSUD systems. Sufficient funding and effective market incentives are required.	Provide financial incentives for WSUD.	Funding sources for the installation and ongoing operation and maintenance of WSUD practices are unclear.
Acceptance of WSUD		Build community acceptance of WSUD by designing WSUD infrastructure, which is an attractive part of the urban landscape.	Employ WSUD at the catchment and streetscape scales, to demonstrate the benefits of WSUD. Educate the community, to build acceptance and support for WSUD, and to reduce potential concerns.		Targeted, interactive programs can be used to educate and engage the community.		Local government staff generally seen as not supportive of WSUD, due to potential risks and maintenance costs.	Lack of widespread support for WSUD across the community, including concerns about its affordability. Lack of political and senior management support.	There has been inadequate community engagement with WSUD, potentially undermining support for the concept. The community can be involved in developing local WSUD policies and in project design.	There is resistance to changes to established practices. There are perceived public health risks.	Lack of community acceptance and perceived social impacts are impediments to the adoption of WSUD.	Some stakeholders associate additional public health and environmental risks with WSUD, compared with conventional practices.
Partnerships and capacity building						Implement capacity building programs, which should include review and continuous improvement processes.		There is a lack of awareness and training related to WSUD. Enhance cooperation between peers.		Institutional capacity to deliver WSUD is inadequate.	There are inadequate skills and knowledge related to WSUD.	Improve the capacity of local government to implement WSUD.
Other factors					Optimal urban stormwater management outcomes are likely to be achieved via a balanced, synergistic combination of structural and non-structural controls.			There is a need for appropriate risk-management, frameworks, in the context of some responsibilities devolving to residents.	Responsibilities related to the implementation of WSUD are fragmented.	Procedures to identify the sustainability and broader impacts of WSUD systems are lacking.		Improve knowledge about how small-scale, distributed systems contribute to meeting objectives at the catchment level.

Source: Original table

The studies summarised in Table 3.5 clearly point to a number of influences on WSUD practices. Importantly, they consistently suggest that the regulatory framework has the capacity to influence the implementation of WSUD. Many of the report explicitly identify the land use planning system as a regulatory element that influences, either positively or negatively, the implementation of WSUD practices (Campbell 1994; Wong and Eadie 2000; Lloyd 2001; Lloyd, Wong, and Chesterfield 2002; Taylor and Wong 2002a; Taylor and Wong 2002b; Taylor and Wong 2002c; Taylor and Weber 2004; Gardiner and Hardy 2005; Chandler and Eadie 2006; Tjandraatmadja et al. 2014). Roy et al.'s comparison (2008) of US and Australian practices at the national level recommends a more explicit legislative mandate for WSUD. While this is a generic comment, it is consistent with including more direct encouragement for WSUD in the land use planning system. Sharma et al. (2012) also refer to the need for what they describe as more supportive governance, regulations and guidelines, which could include land use planning. Collectively, these authors suggest that the land use planning system has the ability to influence WSUD practice.

The studies summarised in Table 3.5 examine a range of factors reported to influence WSUD practice and do not attempt to isolate the specific influence of land use planning. The next section examines studies that focus on the nexus between land use planning and the implementation of WSUD.

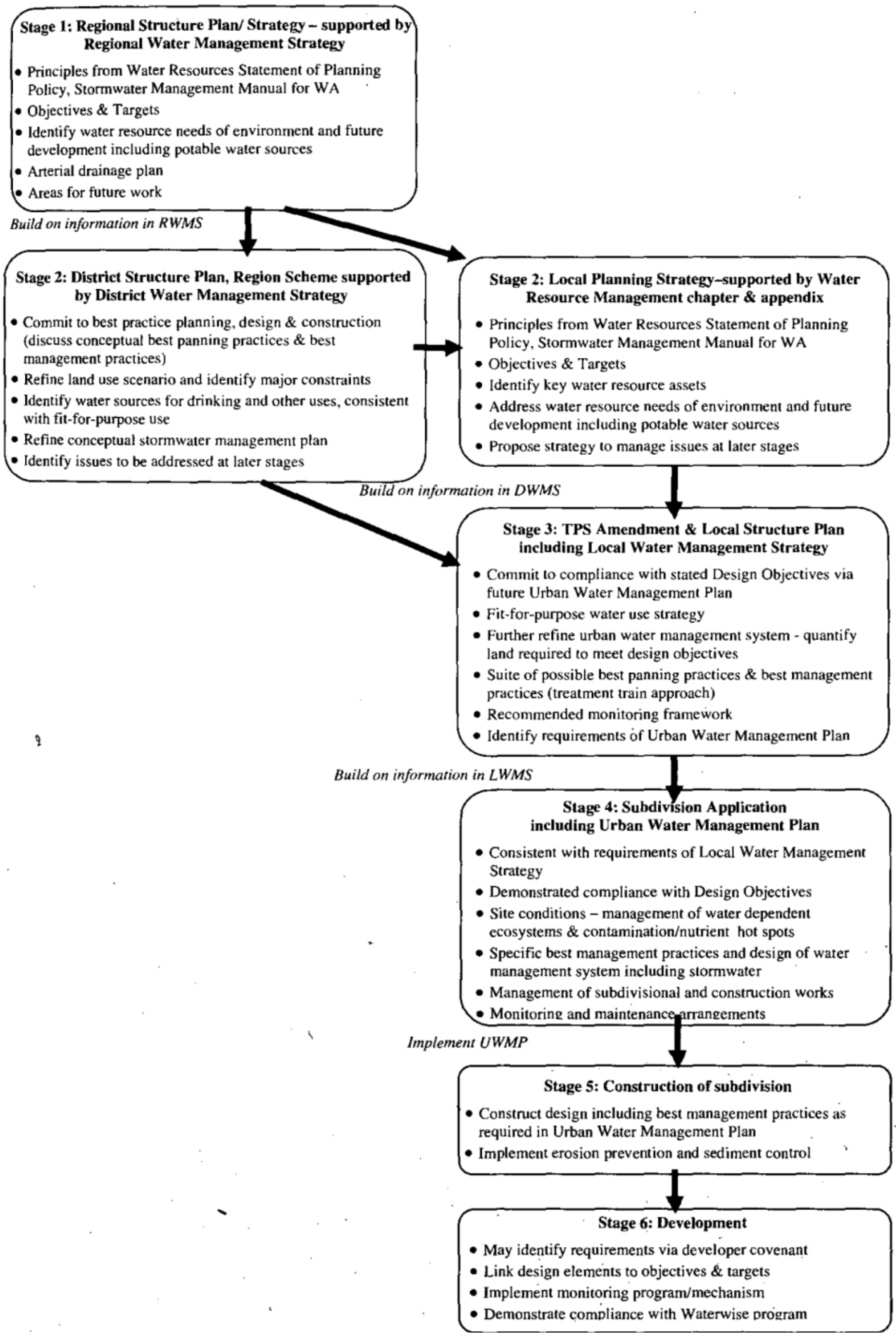
3.3.2 Literature about the Influence of Land Use Planning on WSUD Practices

The previous section showed that studies about influences on the adoption of WSUD consistently identify land use planning as one of the factors that should be considered. Despite this, research specifically examining the relationship between land use planning and WSUD is not extensive. This section examines research that has been reported.

The ability of land use planning tools that include specific quantitative targets to affect WSUD outcomes is discussed by Kay et al. (2004), Stone Jr (2004) and Sands (2014). Kay et al. (2004) suggest that residential lots be evaluated for compliance with a stormwater treatment target, to be specified in the planning system. Their proposed use of a treatment target and evaluation process is consistent with the quantitative targets suggested by Taylor and Weber (2004), and Chandler and Eadie (2006). Stone Jr (2004) describes an investigation of the influence of land use planning regulations on the WSUD practice of limiting impervious surfaces in residential developments. Impervious surfaces such as roofs, paved streets and driveways disrupt the natural water cycle by mechanisms such as reducing groundwater recharge and increasing the volume and rate of stormwater runoff. Therefore, reducing impervious areas is good WSUD practice (Arnold Jr and Gibbons 1996; Brabec, Schulte, and Richards 2002; Walsh, Fletcher, and Ladson 2005; Fletcher, Andrieu, and Hamel 2013; Vietz et al. 2014). Stone Jr (2004) establishes a statistical relationship between impervious area and attributes that can be influenced by planning regulations, such as lot size, lot frontage, street width and distance from lot frontages to houses in Madison, Wisconsin and recommends changes to planning regulations to reduce impervious areas. Sands (2014) describes a similar study, with similar results, in Amherstville, Ontario. These studies consider how land use planning regulations can encourage particular aspects of WSUD practice and are therefore useful. However, they do not provide insights about how the land use planning system can be designed to foster the implementation of a comprehensive range of WSUD practices.

A broader approach is taken by Mouritz and Shepherd (2006), who discuss the capacity of the land use planning system to encourage the incorporation of WSUD practices in new urban developments, based on procedures trialled at an urban growth site in Perth, West Australia. They describe a framework to integrate urban water management with the West Australian land use planning system. The framework, shown in Figure 3-1, was developed as part of a project to identify how water management requirements could be considered at different stages of the land use planning process.

Figure 3-1: Proposed Framework to Integrate Urban Water Planning with the Western Australian Land Use Planning System



Source: Mouritz and Shepherd (2006), 587

This schematic identifies a depicts a number of stages and interactions, but four key elements can be identified. These are, firstly, water management plans being prepared at each stage of the land use planning process, secondly, the inclusion of these water management plans in the planning documentation at each stage, thirdly, water management requirements being mandated via building plans when subdivision occurs, and fourthly, the level of information in each management plan reflecting risk levels. Mouritz and Shepherd (2006) argue that setting specific targets and objectives for water quality and quantity provides clear benchmarks for WSUD outcomes and fosters innovation: this finding is consistent with the views of Taylor and Weber (2004), and Chandler and Eadie (2006), that quantitative targets are one of the elements of an effective policy framework.

While Mouritz and Shepherd base their recommendations on a trial to integrate urban water management and land use planning, they do not describe how their integrative framework was developed and evaluated, or the information they used to reach their conclusions. This makes it difficult to determine the robustness of their conclusions. That said, Mouritz, Evangelisti, and McAlister (2006) support the approach suggested by Mouritz and Shepherd to aligning urban water and land use planning. They state that: 'it is possible to build a conceptual framework of how to achieve WSUD outcomes, through identifying specific actions and investigations to be undertaken at each of the scales or levels of planning. This will ensure that decisions on land use…will facilitate WSUD outcomes' (2006, 4-9).

Shepherd (2014) provides further information about the influence of Western Australia's land use planning system on WSUD outcomes. Shepherd indicates that, during the period she considers, the Western Australian regulatory system included the staged approach to integrating land use and water resource planning suggested by Mouritz and Shepherd (2006).[19] She states that the best WSUD outcomes are obtained when urban water management is considered at the district, local and subdivision approval stages of the land use planning process. Deferring consideration to the subdivision approval stage means that it is too late to 'facilitate ecological outcomes, alternative water and wastewater servicing/reuse, or ensure sufficient land is identified to adequately manage surface water flows and quality' (Shepherd 2014, 32). Shepherd's view that WSUD outcomes are optimised when urban water management is considered at successive stages of the land use planning process is consistent with Mouritz and

[19] Shepherd considers urban development that occurred after 2008, when the Western Australian government adopted the policy document *Better Urban Water Management* (Western Australia. Western Australian Planning Commission 2008a). This policy links water resource and land use planning in a similar way to that recommended by Mouritz and Shepherd (2006).

Shepherd (2006) and Mouritz, Evangelisti, and McArthur (2006). Notwithstanding these comments about the need to align land use planning and urban water management at multiple levels, an important additional comment by Shepherd is that an informal review of planning documentation and WSUD outcomes suggested that only limited improvements to the management of the urban water cycle had, in reality, been achieved by the planning process (Shepherd 2014, 31). This indicates that further investigations, to better understand the relationship between the land use planning regulatory environment and WSUD outcomes, are warranted.

Corbett (2012) describes efforts to coordinate land use planning and urban water planning in another Australian jurisdiction, based on experiences in Melbourne, the capital of the state of Victoria. He considers the influence of Precinct Structure Plans (PSPs), which are master plans to guide future development in urban growth corridors. PSPs include 'Integrated Water Management Plans'. Corbett outlines three cases where PSPs are said to have encouraged WSUD practices, such as the collection and reuse of stormwater, rainwater and treated effluent, and reductions in stormwater discharges to receiving streams. While Corbett states that other PSPs had failed to foster sustainable urban water practices, and that more should be done to mainstream WSUD, he does not provide a detailed analysis of the factors he believes determine the ability of PSPs to encourage WSUD practices. Corbett makes the general suggestion that more sophisticated investment and risk assessment frameworks are required (2012, 2960), but does not indicate how such frameworks could be integrated with the land use planning process.

A further limitation of Corbett's discussion is that it focuses on the influence of PSPs in urban growth corridors, instead of examining Melbourne's planning regulatory framework as a whole. This framework includes Clause 56.07 of the Victoria Planning Provisions[20], which is intended to facilitate the implementation of WSUD at the subdivision stage (Victoria. Department of Sustainability and Environment 2006). The introduction of this requirement in 2006 is claimed to have been a major factor in Melbourne's transition to more sustainable urban stormwater management practices

[20] *Victoria Planning Provisions 2006 (Vic*), cl 56.07.

(Brown and Clarke 2007; Potter and RossRakesh 2007). The influence of Clause 56.07 on WSUD practices other than stormwater management is considered by Wong et al. (2011), who claim that, although the clause allows water recycling to be considered at the subdivision stage, a wider policy framework for recycling is lacking, which should be addressed by the Victorian state government. De Sousa and Harders (2012) state that, in their view, although Clause 56.07 refers to recycling, it concentrates on managing risks, instead of positively encouraging this practice. It appears that, while Clause 56.07 may have supported improved urban stormwater management, it may well not have facilitated the recycling components of WSUD practices.

Also based on research carried out in Melbourne, Nunes et al. (2011) propose a three stage process (BLUE Plan) to integrate WSUD with site-specific statutory planning requirements for urban developments. The three stages are:

1. a review of site-specific WSUD technical requirements
2. the identification of local environmental and planning conditions
3. the design of specific WSUD treatment measures compatible with the planning and building regulatory regime for the site.

The process was used to design streetscape scale WSUD measures for an urban renewal project. However, further use of BLUE Plan has not been reported, suggesting that it has had little impact on WSUD practice.

Further information about the influence of land use planning on WSUD practices is provided by a study based on interviews with thirteen Australian urban water management and land use planning practitioners (Cooperative Research Centre for Water Sensitive Cities 2014a). This study concludes that land use planning has the capacity to encourage WSUD practices, but legislation should be revised, to provide a stronger legislative mandate for WSUD. Another interesting finding is that the views of the practitioners about mandatory targets were divided. While there was, on the one hand, some support for these targets, on the other, there was opposition to them from several participants. This opposition was based on a view that specific, mandatory targets foster a lowest common denominator approach to implementing WSUD practices, which discourages innovation.

This section examined literature about the influence of land use planning on the implementation of WSUD. The next section provides an overview of the literature examined in 3.3.1 and 3.3.2.

3.3.3 Analysis of Literature about Influences on WSUD Practices

Sections 3.3.1 and 3.3.2 described a range of literature, which suggests that regulatory frameworks, including land use planning, have the capacity to influence the implementation of WSUD. This section, firstly, identifies strong support for the use of explicit targets to foster WSUD practices. Secondly, it identifies limitations of these studies, in addition to those that have already been mentioned in passing, which demonstrate clearly that further research about the connection between land use planning and the adoption of WSUD practices is warranted.

Specific, quantitative targets are suggested as important parts of the regulatory framework for WSUD by a number of authors (Taylor and Weber 2004; Kay et al. 2004; Chandler and Eadie 2006; Mouritz and Shepherd 2006; Potter and RossRakesh 2007; Corbett 2012, 2959; Tjandraatmadja et al. 2014, 81). This approach is suggested in the context of discussions about land use planning regulation (Taylor and Weber 2004; Kay et al. 2004; Potter and RossRakesh 2007), controlling the concentrations of specific pollutants in stormwater runoff (Chandler and Eadie 2006), setting clear benchmarks and fostering innovation (Mouritz and Shepherd 2006), changing previously entrenched stormwater management practices (Potter and RossRakesh 2007), as part of a strategy to reduce the demand for drinking water from the centralised supply system (Corbett 2012, 2959) and encouraging the adoption of WSUD practices in South Australia (Tjandraatmadja et al. 2014, 81). Collectively, these authors suggest that fixed quantitative targets provide clear, unambiguous signals and should be an integral part of the regulatory regime for WSUD practices.

Turning to the limitations of these studies, their focus on different parts of the WSUD concept means that caution is required when the findings of different authors are compared. For example, Campbell (1994), Lloyd, Wong, and Chesterfield (2002), Taylor and Wong (2002a; 2002 b; 2002c), Kay et al. (2004) and Roy et al. (2008) focus on urban stormwater management, whereas Wong (2006a), Mouritz and Shepherd (2006), Corbett (2012) and Shepherd (2014) discuss the urban water cycle as a whole, and its interaction with urban design. These differing emphases reflect the varying interpretations of WSUD discussed in Chapter 2. It is not clear that findings that relate to, for example, urban stormwater management can simply be extrapolated to the complete urban water cycle.

A further point that emerges from 3.3.1 and 3.3.2 is the extensive reliance on evidence such as surveys, and individual experience and opinions. While the literature consistently states that the regulatory environment, including land use planning, influences the implementation of WSUD, there has been insufficient empirical investigation of the nexus between land use planning and the adoption of specific WSUD practices. The research reported in this thesis provides a detailed, fine-grained empirical analysis of how land use planning influences the implementation of WSUD practices and addresses a gap in prior scholarship.

As well as research about the influence of discrete factors on the implementation of WSUD, broader socio-political and cultural forces said to affect WSUD practice have also been investigated. The next sub-section examines this approach.

3.3.4 Socio-Political Environment for WSUD

As the discussion about influences on WSUD practice matured, scholars broadened their investigations, beyond an examination of technical and institutional factors, to consider how the wider socio-political environment affects the implementation of WSUD. The distinction between these two dimensions is not precise, and they do overlap, to a degree. Nonetheless, the broadening of scholarship to explicitly consider the socio-economic environment did provide a new focus for research, which merits examination. This section briefly examines this scholarship and its connection with the research reported in this thesis.

While not completely focused on WSUD, Brown, Sharp, and Ashley (2006) usefully articulate this broader analytical approach when they examine obstacles to the implementation of sustainable urban water management practices. They analyse three examples from the urban water sector, where efforts to implement technical solutions to improve practices deemed unsustainable were not successful in bringing about change. These examples are urban stormwater management in New South Wales, Australia; sanitary waste management in the UK water industry; and the implementation of innovative water saving techniques in the UK private housing sector. Brown, Sharp, and Ashley conclude that 'challenges are entrenched within the broader socio-political framework, yet often unsuccessfully addressed within the more narrow scope of improving technical knowledge and design capacity' (2006, 415). Brown, Sharp, and Ashley recommend strategies such as political leadership, institutional reform and social change to encourage the adoption of sustainable urban water practices. In the context of WSUD, this suggests that its implementation may be affected by the wider socio-political landscape and not just a range of more proximate factors.

Morison and Brown (2007) consider this broader context in an examination of the joint efforts of state and local governments to implement WSUD policies. The need for research of this type is highlighted by Lloyd (2001), Lloyd, Wong, and Chesterfield (2002), Gardiner and Hardy (2005) and Tjandaatmadja et al. (2014), who suggest that a fragmented regulatory framework at the local and state government levels hinders the implementation of WSUD. Morison and Brown review the effectiveness of two programs where the state government of New South Wales worked with local governments to implement WSUD policies via a coercive, rule-based approach in one program and a cooperative approach, using financial and technical support, in the other program. Morison and Brown conclude that, under both approaches, significant numbers of local governments exhibited low degrees of commitment to the policies. Local government commitment to implement WSUD policies varied across a broad spectrum. Morison and Brown (2007) recommend that higher levels of government use tailored policy measures to achieve good outcomes across the range of local government commitment, with measures being tested and adjusted as required.

Morison and Brown (2011) use a case study in Melbourne, Australia, to assess how local government commitment to WSUD is influenced by a range of factors and to identify groups of local governments with significantly different attitudes to WSUD. The research is intended to inform the design of intergovernmental WSUD programs. Morison and Brown classify local governments into three groups, exhibiting high, partial and limited commitment to WSUD policies, and suggest suites of policies that state government could use to encourage the implementation of WSUD by each of these groups. They believe that building local support for WSUD and transferring knowledge would be appropriate for the limited commitment group, while measures relying on tailored local solutions and expanding the perceived scope of WSUD would be appropriate as levels of commitment increase. They suggest that regulations mandating compliance with minimum WSUD standards and targets may be required for the limited commitment group (Morison and Brown 2011, 91).

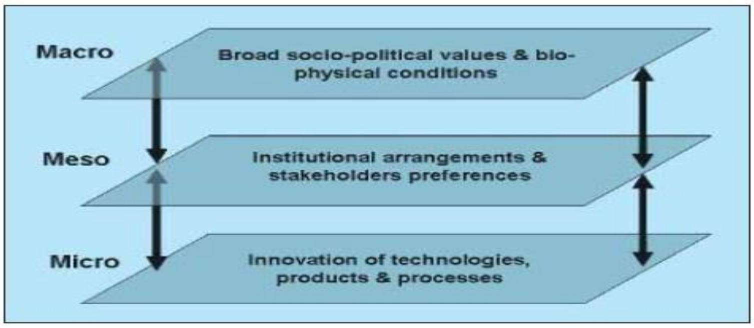
Another approach to placing the adoption of WSUD practices in a wider socio-political context uses concepts from transition theory. Transition theory can be used to examine factors which resist, or facilitate, the propagation of newly emergent ideas that challenge existing paradigms (Rotmans, Kemp, and Van Asselt 2001; Rijke et al. 2008). This theoretical approach provides a framework to understand influences such as institutional inertia, fragmented responsibilities, regulatory obstacles and lack of skills and knowledge, which have been reported to hinder the uptake of sustainable urban water management practices (Lundqvist, Turton, and Narain 2001; Mitchell 2004; Brown 2005; Saleth and Dinar 2005; Brown, Sharp, and Ashley 2006; Brooks, Brown, and Morison 2010).

Brown and Clarke (2007) use transition theory to analyse the adoption of the urban stormwater quality management (USQM) element of WSUD in Melbourne, Australia. Brown and Clarke report that USQM is well advanced on a transition pathway towards being recognised as mainstream practice. They analyse USQM's adoption in terms of the interaction between factors operating at three levels in a multi-level perspective, adapted from the work of Rip and Kemp (1998):

1. Macro-level: socio-political and bio-physical systems
2. Meso level: institutional level, including water industry, regulators, government policy makers
3. Micro level: technical and product development level.

These are shown in Figure 3-2, following:

Figure 3-2: Levels in Brown and Clarke's Multi-level Framework for the Adoption of USQM



Source: Brown and Clarke (2007), 7

Brown and Clarke state that changing institutional cultures and values is critical to successfully implementing the comprehensive WSUD agenda and that the role of champions, who interact with their environment in complex ways, is also important.

From the perspective of this thesis, key points from Brown and Clarke's work are:

1. The influences on WSUD practice discussed in sections 3.3.1 and 3.3.2 are institutional, technical and operational factors, which fall within the meso and micro levels of the multi-level perspective in Figure 3.2.
2. The meso level includes '…the formal and informal 'rules'…that have a role in shaping the management of the urban water environment…' (2007, 6), indicating that land use planning regulatory frameworks would be placed at this level.
3. The adoption of Clause 56.07 of the Victoria Planning Provisions (a statutory land use planning tool) was said to be a key factor supporting USQM's progress towards acquiring mainstream status (2007, 53).

A similar analysis based on transition theory and a multi-level framework compares the progress towards making WSUD mainstream practice in Melbourne and the Netherlands, using evidence from case studies (Rijke et al. 2008). It concludes that, in both locations, the transition pathways for the adoption of WSUD are similar and the key factors facilitating or inhibiting the adoption of WSUD at the macro, meso and micro levels are broadly analogous. At the macro level, these factors relate to climate, urban growth and the socio-political landscape; at the meso level they relate to interactions between institutional actors, the regulatory environment and costing; and at the micro level they relate to the design, performance and evaluation of new technologies, and the presence of individual champions who can drive change.

Other studies describe the application of transition theory to investigate the adoption of sustainable urban stormwater management (Ferguson, Frantzeskaki, and Brown 2013), the transition to a water sensitive city (Brown, Farrelly, and Loorbach 2013), to water resource management generally (Van der Brugge, Rotmans, and Loorbach 2005; Van der Brugge and Rotmans 2007), and ultimately to sustainable development (Loorbach 2010). This research suggests that a coherent strategic transformation program and institutional reform are influential factors in the uptake of sustainable urban water practices. While this claim may contribute to understanding the complete range of factors that influence the adoption of WSUD, it does not inform the current research about the specific role of land use planning and will not be examined further.

Another approach, which places WSUD in a particularly broad context, is described by Ward et al. (2012). They characterise the implementation of WSUD as a process, which ultimately leads to water sensitive cities as the outcome, consistent with Wong et al. (2011) and Wong et al. (2012). Ward et al. consider the insights provided by implementing WSUD in a variety of development contexts and countries, including Singapore, France, the United Kingdom, the United States and Australia. They state that achieving the aspirations of WSUD will require a trans-disciplinary approach, which values old and new knowledge, and connects disciplines via a shared language. Looking beyond urban water management, Ward et al. (2012) argue that WSUD could provide a template to address a range of sustainability issues, such as low carbon living, housing, transport, public health and energy use, in what they describe as the multi-objective 'City of the Future'. While this view of the role the WSUD concept might play in furthering a broad range of sustainability issues is interesting, it appears to highlight what could generally be regarded as good professional practices. It does not provide clear insights to guide the current research and will not be considered further.

Having discussed how the broad socio-political environment may affect the implementation of WSUD, it would be useful to consider how this scholarship relates to the current research. It might be argued that investigations about the broad context for WSUD make research about specific influences of secondary importance. However, this argument fails to consider that investigating specific influences, such as the land use planning system, contributes to a better understanding of the influences located at various levels in Brown and Clark's multi-level framework (2007, 7) and the interactions between the various levels. For example, better knowledge about how land use planning, located at Brown and Clark's meso level, influences WSUD practices should inform analyses of political attitudes to WSUD, at Brown and Clark's macro level. A truly comprehensive understanding of the factors that influence the adoption of WSUD practices is best gained by integrating research about specific influences, such as the current research, and research about the broader socio-political environment. Therefore, the research described in this thesis makes a useful contribution to understanding the broad range of factors, at a range of levels, that influence the adoption of WSUD practices.

This section shows that previous scholarship has identified regulation, including land use planning regulation, as one of the factors that influences the adoption of WSUD practices. We now turn to the statutory land use planning systems in Australian jurisdictions.

3.4 Land Use Planning Regulatory Framework for WSUD in Australian Jurisdictions

This section briefly examines the current land use planning legislative environment for WSUD in several Australian jurisdictions. Section 3.4.1 defines land use planning, in the context of the research carried out for the thesis, and Section 3.4.2 examines the allocation of land use planning responsibilities in Australia's federal system. Section 3.4.3 identifies and compares the land use planning regulatory environments for WSUD in Australia's mainland states.

3.4.1 Definition of Statutory Land Use Planning

A number of approaches to defining land use planning have been suggested. The International Society of City and Regional Planners describe land use planning as a process for 'regulating and promoting changes in the use of land and buildings' (International Society of City and Regional Planners (ISOCARP) 2001, xi). Gurran suggests that, in the urban context, a number of terms, including urban planning, town and country planning, land use planning, environmental planning and spatial planning describe ‘a formal process regulating the use of land and the development of the built environment, in order to achieve strategic policy objectives’ (2011, 15). Gurran’s focus on policy outcomes is supported by Eccles and Bryant (2011), who argue that land use planning is a process that uses a range of implementation mechanisms to address current or anticipated policy issues, with continuous evaluation of both the issues and the mechanisms applied to resolve them.

This thesis follows the approach of Gurran and defines statutory land use planning as:

> the statutory regulation of land use and development, to meet public policy objectives.

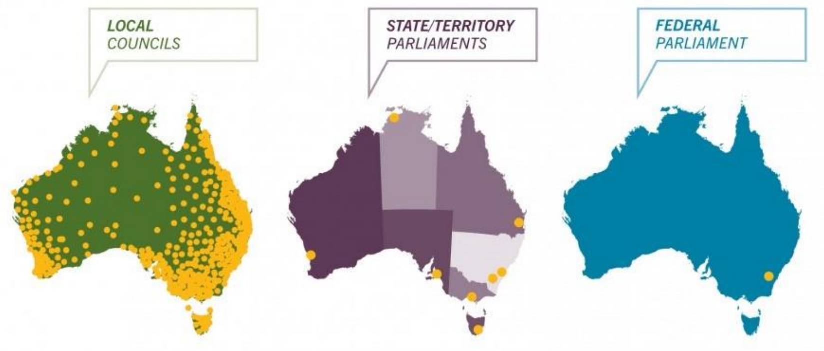
This definition is consistent with Freiberg’s (2010) intellectual framework which, as noted in Chapter 1, seeks to understand the role that laws, and other regulatory tools, play in meeting public policy objectives, and examines how laws affect social and professional practices.

The term ‘statutory land use planning system’ is also used as a broad concept which includes statutory land use planning legislation and regulation, the administrative processes used to implement legislation and regulation, and the relevant actors.

3.4.2 Allocation of Land Use Planning Responsibilities between Different Levels of Government in Australia

Before examining land use planning regulation in Australia, the hierarchy of Australian governments needs to be described. Australia is a federation, rather than a unitary state, and responsibilities and powers are divided between a central national government and the individual states and territories (Australian Government n.d.). The central government is the Australian Government, sometimes referred to as the Commonwealth Government. The states and territories have also established a separate local government tier, so Australia has, in total, three levels of government, Commonwealth, State and local. Australian local governments are also often referred to as councils, because the elected representatives make up the ‘council’, which administers each local government area. Each local government regulates a specific geographic area, in accordance with the powers, duties and responsibilities delegated to it by the state/territory government (Gurran 2011, 85). These three tiers of government are shown in Figure 3-3:

Figure 3-3: The Three Levels of Government in Australia



Source: Australia. Parliamentary Education Office n.d.

The matters for which the Australian Government has explicit authority to make legislation are set out in Section 51 of the Australian Constitution, which does not mention the environment (Gurran 2011, 84). As a result, the main responsibility for land use planning legislation resides with the states and territories (Harding 1998). They in turn have established legislative regimes which largely delegate the operation of the land use planning system to local government, including tasks such as identifying local issues and priorities, preparing statutory land use plans and making decisions about development applications (Gurran 2011, 85). There are some variations from this overall pattern, such as the establishment of a separate statutory authority by the Victorian state government to coordinate urban planning in the growth corridors of Victoria's capital, Melbourne, which are described as needed in this thesis.

As the main responsibility for land use planning in Australia lies with the states and territories, the next section examines the land use planning legislative terrains, related to WSUD, in the mainland Australian states.

3.4.3 WSUD and Land Use Planning Regulation in Mainland Australian States

Choi, McIlrath and Williams (2015) review the statutory land use planning systems in the mainland Australian states of Queensland, New South Wales, Victoria, South Australia and Western Australia. They identify and compare requirements related to WSUD and show that the statutory environment for WSUD varies markedly between these jurisdictions. Their findings are shown in Table 3-6, following:

Table 3-6: Comparison of Statutory Land Use Planning Requirements for WSUD in Australian Jurisdictions

State	Important Statutory Land Use Tools Related to WSUD	Focus of Tools
Queensland	State Planning Policy: State Interest – Water Quality (Queensland. Department of Infrastructure Local Government and Planning 2016)[21] South East Queensland Regional Plan 2009-2031 (Queensland. Department of Infrastructure and Planning 2009)	Urban stormwater management, particularly flood management
New South Wales	There are no general state policies or statutory provisions related to WSUD. However, some specific 'environmental planning instruments'[22] made under the *Environmental Planning and Assessment Act 1979* (NSW) include requirements related to urban water management, particularly water conservation.	Water conservation
Victoria	Victoria Planning Provisions Clause 56.07, Integrated Water Management[23] *Urban Stormwater - Best Practice Environmental Management Guidelines* (Victoria. Stormwater Committee 1999)	Urban stormwater management
South Australia	30 Year Plan for Greater Adelaide (South Australia. Department of Planning and Local Government 2010) Water sensitive urban development: Creating more liveable and water sensitive cities in South Australia (South Australia. Department of Environment Water and Natural Resources 2013)	Water security, including stormwater reuse
Western Australia	State Planning Policy 2.9, Water Resources[24] *Better Urban Water Management* (Western Australia. Western Australian Planning Commission 2008a)	Urban stormwater management and groundwater protection

Source: adapted from Choi, McIlrath and Williams (2015).

The above table indicates that there are significant differences between the approaches to WSUD in the statutory land use planning systems in the five mainland Australian states. Choi, McIlrath and Williams (2015) note differences in how WSUD is defined, the types of statutory tools that include WSUD requirements, the legal status of water quality policies and a proliferation of non-statutory guidance, which varies greatly between jurisdictions and is difficult to navigate.

[21] The State Planning Policy was re-issued in April 2016, that is, after Choi, McIlrath and Williams' (2015) review. However, the State Interest – Water Quality was not varied in the 2016 re-issue.
[22] 'Environmental planning instruments (EPIs) is the collective name for Local Environmental Plans (LEPs), State Environmental Planning Policies (SEPPs), and Regional Environmental Plans (REPs)…The provisions of EPIs…are legally binding on both government and developers' (New South Wales. Department of Planning and Environment n.d.).
[23] The Victoria Planning Provisions are delegated legislation, made under the part 1A of the *Planning and Environment Act 1987* (Vic).
[24] Western Australian Planning Commission *Government Gazette WA* Special Gazette No 227 State Planning Policy 2.9 Water Resources 19 December 2006, 5708.

3.5 Conclusions

This chapter examined the literature about influences on WSUD practice. Many authors suggest that land use planning regulation has the ability to influence WSUD outcomes, either favourably, via a well-articulated framework that includes suitable policies, legislation, objectives and approval procedures, or unfavourably, via a framework that lacks these features. However, these inferences have largely been drawn from professional judgements and stakeholder opinions, rather than empirical studies. There are further limitations of the literature that was reviewed. Despite the suggestion that appropriate regulatory frameworks can support WSUD practice, guidance about the characteristics of such supportive frameworks is limited. There is some support for quantitative standards and targets (Kay et al. 2004; Taylor and Weber 2004; Chandler and Eadie 2006; Mouritz and Shepherd 2006; Potter and RossRakesh 2007; Corbett 2012, 2959; Tjandaatmadja et al. 2014, 81) and a suggestion to align land use planning and water resource planning to produce sound WSUD outcomes, based on experience from Perth, Western Australia (Mouritz and Shepherd 2006; Shepherd 2014). However, descriptions of well-defined, empirically grounded models for land use planning regulatory frameworks that lead to effective WSUD practice are lacking.

The literature suggests a number of factors that may influence WSUD practice, which are summarised in Table 3.7. Positive influences have been reported to include a consistent, coherent regulatory framework; specific quantitative targets; a strong legislative mandate for WSUD; integration of regulation across and between levels of government; considering urban water management throughout the land development process; and development being master planned and subject to regional water quality targets. Negative influences may include a fragmented, inconsistent regulatory framework; the development of innovative approaches being inhibited by overly prescriptive regulation, the regulatory framework being overly complex and difficult to navigate; uncoordinated regulation across and between levels of government; and urban water management only being considered at the subdivision stage.

There are some tensions in these reported influences: the recommendations for specific quantitative targets contrast with the view that targets discourage innovation and the development of a stronger legislative mandate for WSUD may not assist the simplification of what has been described as an overly complex regulatory framework.

Table 3-7: Reported Positive and Negative Influences on the Implementation of WSUD Practices

Positive Influence	Negative Influence
• Coherent, consistent regulatory framework • Strong legislative mandate for WSUD • Quantitative targets • Regulation across and between levels of government is integrated • Urban water management is considered at the start of the land development process and then at subsequent stages • The development site is subject to master planning and regional water quality targets	• Fragmented, inconsistent regulatory framework • Overly complex, difficult to navigate framework • The development of innovative approaches is inhibited by overly prescriptive regulation • Regulation across and between levels of government is ineffective and inconsistent • Urban water management is only considered at the subdivision stage

Source: original table

In summary, there is little rigorous, empirically based knowledge about how planning frameworks influence WSUD practice and a lack of broad theoretical propositions and competing schools of thought. This inadequate knowledge base is consistent with the claim by Sharma et al. (2012, 344) that there is a need for further research about the links between land use planning systems and urban water management. The research question in this thesis addresses this need.

Important characteristics of the land use planning regulatory frameworks, as they relate to WSUD, in Queensland, New South Wales, Victoria, South Australia and Western Australia were discussed, highlighting marked variations between these jurisdictions. This suggests that, ideally, the research would identify broad approaches to designing statutory land use planning systems that are sympathetic to WSUD practices, which could be adopted to a range of statutory settings.

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Chapter 4

DESIGN OF THE EMPIRICAL RESEARCH

4.1 Introduction

This Chapter considers the design of the empirical component of the research. It describes the overall research design, including the specific methods used to collect, analyse and interpret information. It also considers the extent to which the findings can be applied generally.

Section 4.2 outlines factors that influenced the design of the research and why, after considering them, a design including a survey and a series of case studies was adopted. It also shows how the research design ensured that the findings of the survey and the case studies addressed the research question.

Section 4.3 considers the sources, and types, of information gathered during the empirical research. The ability to generalise the research findings is considered in Section 4.4 and is followed by some concluding remarks in Section 4.5.

4.2 Research Design

This section describes the overall plan, or design, of the empirical research, where the 'research design is the logic that links the data to be collected (and the conclusions to be drawn) to the initial questions of study' (Yin 2014, 26).

As Yin's definition above indicates, the research design must ensure there is a direct connection between the way information is collected and analysed, and the research question. In the research reported here, the research question related to the behaviour of social systems, organisations and actors. The investigation could thus be characterised as social research, in contrast to research of phenomena occurring in the natural world.

A useful analysis of the methods employed in social research is provided by Swanborn (2010), who states that they can be broadly divided into extensive and intensive categories. This approach draws on ideas put forward earlier by Harre (1979). According to Swanborn, extensive research is used to investigate phenomena via statistical techniques: it is used to 'collect information about the relevant properties of a large number of instances of a phenomenon' (2010, 1) in order to 'create information about frequency distributions and relationships between the variables under study, which might be helpful in understanding and explaining the phenomenon' (2010, 2). In contrast to statistically based extensive research, intensive social research examines either a single example, or a small number of examples, of a phenomenon, in order to study that phenomenon in depth (2010, 2). This intensive study 'helps us to describe and explain the history, the changes during the period under study and the complex structure of the phenomenon' (2010, 2). According to Swanborn, the intensive approach is generally referred to as case-study research (2010, 2). While his definition of a case study is lengthy, it is informative (2010, 22):

A case study is defined as the study of a social phenomenon:

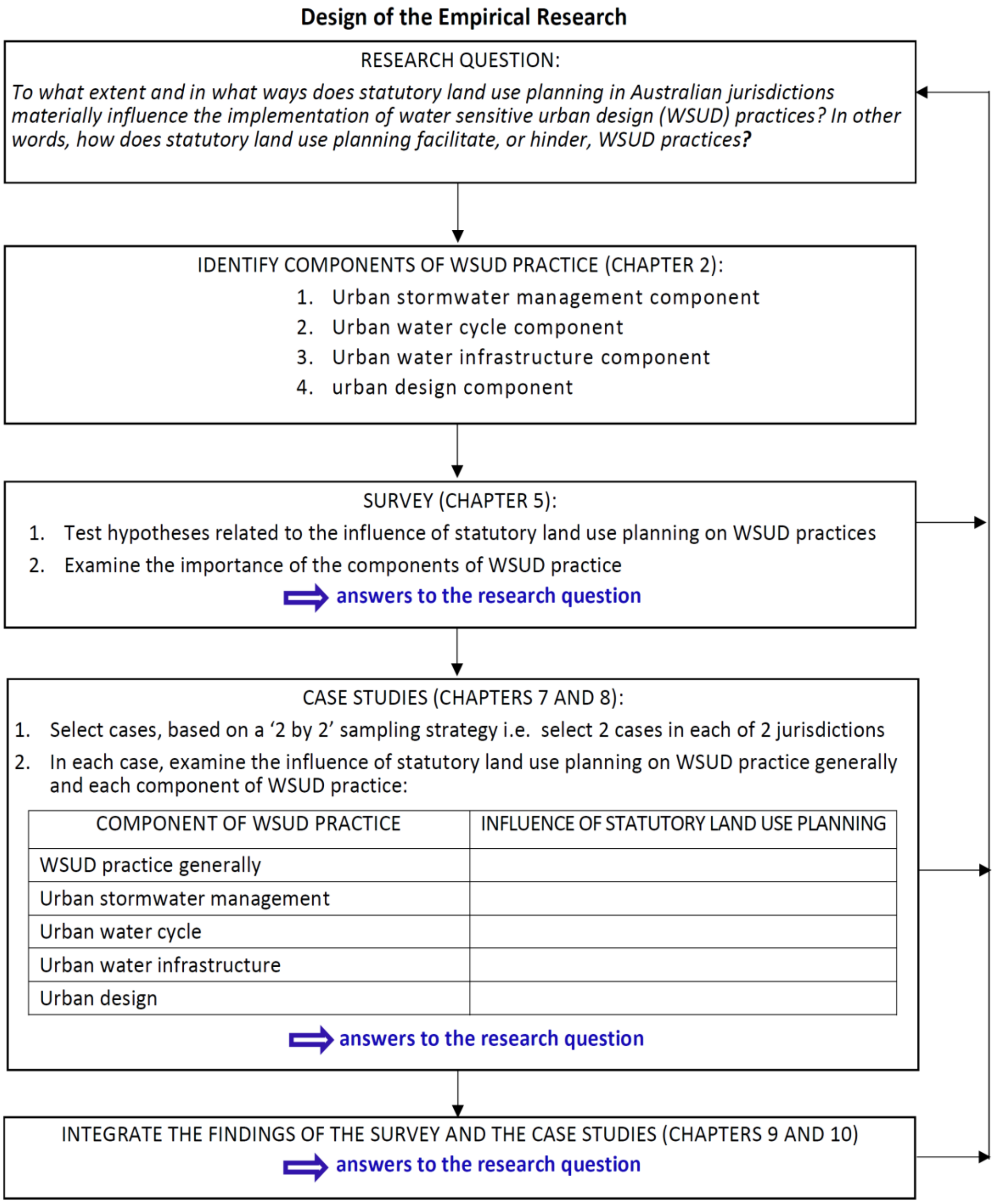
- in one, or only a few of its manifestations
- in its natural surroundings
- during a certain period
- that focuses on detailed descriptions, interpretations and explanations that several categories of participants in the process attached to the social process
- in which the researcher starts with a broad research question on an ongoing social process and uses available theories, but abstains from pre-fixed procedures of data collection and data analysis, and always keeps an eye open to the newly gathered data in order to flexibly adjust subsequent research steps
- that exploits several sources of data (informants, documents, observatory notes)
- in which sometimes the participants in the studied case are engaged in a process of confrontation with the explanations, views and behaviours of other participants and with the resulting preliminary results of the researcher.

Swanborn states that case studies are well suited to investigating broad exploratory research questions (2010, 25). The research question in this thesis is broad. Swanborn's view is consistent with Eisenhardt (1989) and Yin (2014), who both state that the case- study method is an appropriate way to investigate a phenomenon where research and theory in the field are at an early stage. As discussed in Chapter 3, previous research has yielded little empirically based knowledge about how statutory land use planning influences WSUD practice. Given the broad nature of the research question, and the sparse information available from previous scholarly investigations, the case study approach was an appropriate way to carry out the empirical research.

That said, a potential limitation of the case study method is that the ability to apply the findings from the set of cases examined in the research to other settings may depend on a number of conditions: this issue is discussed later in this chapter, in section 4.4. In order to address this potential limitation, the use of a survey, to complement the case studies, was considered. Surveys are examples of Swanborn's extensive research

(2010, 1), that seeks to understand the characteristics of a population as a whole. Thus, a research design that included both a survey (extensive perspective) and case studies (intensive perspective) was developed, as shown in Figure 4.1. This approach utilised the complementary perspectives provided by the two methods, to improve the robustness of the findings.

Figure 4-1: Design of the Empirical Research



Source: original figure

The design integrates:

1. The research question
2. The components of WSUD practice identified in section 2.6
3. A survey of participants from the government, water utility, private and research sectors about the influence of statutory land use planning on WSUD practices
4. A series of case studies, examining how statutory land use urban planning influenced WSUD practices.

The research design uses the results of the survey and the case studies to provide a broad understanding of how statutory land use planning influences WSUD practices, including the components of WSUD practice identified in this thesis. This process answers the research question.

This section provides a general description of the research design. In order to provide a complete description of the research methodology, more detailed information about the procedures used to plan and carry out the survey and the case studies is provided in Chapters 5 and 6, respectively.

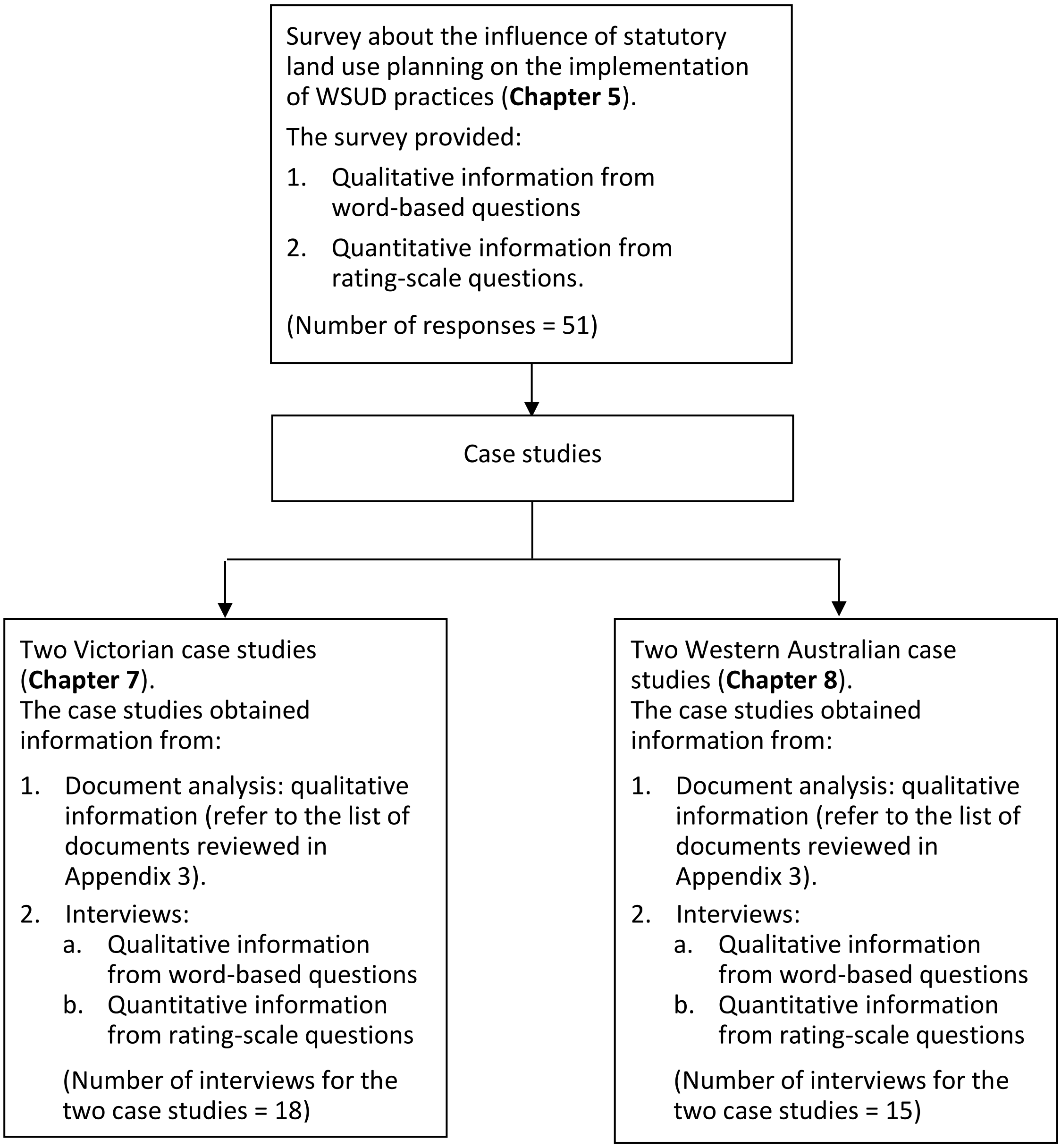
While this section described the overall research design, it is also important to consider the sources and types of information obtained during the research. Section 4.3, which follows, examines this issue.

4.3 Sources and Types of Information used in the Research

The research obtained information from different sources, and of different types. As shown in Figure 4-2, the sources of information were:

1. The survey
2. Document analysis during the case studies
3. Interviews carried out during the case studies.

Figure 4-2: Collection of Empirical Evidence



Source: original figure

The sources, and types, of information obtained in the survey and the case studies may be summarised as shown in Table 4.1, following:

Table 4-1: Sources and Types of Information used in the Research

Source of Information		Did this Source Provide Qualitative Information?	Did this Source Provide Quantitative Information?
Survey		YES	YES
Case studies	Document analysis	YES	NO
	Interviews	YES	YES

Source: original table

Advantages of Obtaining Information from Different Sources

In the research described in this thesis, the case studies provided information from two sources, that is, document analysis and interviews, while the survey was a further source of information. In the context of case studies, Rowley (2002, 23) and Yin (2012, 13) note that case-study findings are considered more reliable when information from a range of sources is available. It seems reasonable to suggest that the robustness of the research findings is further enhanced by using information from another source, that is, the survey, to complement the information from the case studies. Information from different sources can be used in a process referred to as triangulation, which 'uses evidence from different sources to corroborate the same fact or finding' (Rowley 2002, 23). This approach was used in the research described in this thesis. Potential findings were derived, and tested, using information from all the sources. Proposed findings that were consistent with the evidence from different sources were regarded as more reliable than findings that lacked such consistency. That said, possible discrepancies in the evidence from different sources were examined, to see whether the apparent differences could be reconciled by different, possibly more insightful, interpretations.

Advantages of Obtaining Different Types of Information

Broadly, researchers can acquire qualitative (word-based) and quantitative (numeric) information (Creswell 2014). In the current research, the survey and case-study interviews provided qualitative and quantitative information. This approach recognised that the influence of statutory land use planning on WSUD practices can be described in both qualitative and quantitative[25] terms. The two types of information are complementary, with different strengths and weaknesses. For example, quantitative data can be analysed by statistical tests, which are not readily applied to qualitative information. Conversely, two respondents may provide identical numeric responses, but for different reasons, which could only be identified by word-based responses to open-ended questions. Using both numeric and word-based information provides the advantage of 'drawing on both qualitative and quantitative research and minimising the limitations of both approaches' (Creswell 2014, 218). Creswell (2014) classifies

[25] For example, via rating scales.

investigations using quantitative and qualitative information as mixed methods research and states that this approach is now well accepted by scholars engaged in research in the social, human behaviour, evaluation and education fields.

4.4 Generalising Findings

A common goal of a research project is to apply its findings beyond the specific circumstances it investigated to a broader set of phenomena, that is, to generalise the research findings. However, there is a range of views amongst scholars, with some placing weight on the ability to generalise findings, some who dismiss generalisation as not relevant and others who ignore the issue entirely (Lewis and Ritchie 2003). The research question in this thesis is broad and considers how statutory land use planning influences the adoption of WSUD practices in a general sense. The approach adopted in this thesis was to attempt to generalise the findings from the specific phenomena that were investigated, to a broader set of circumstances. However, a range of factors can affect the ability to generalise the findings of surveys and case studies.

Surveys are typically carried out with the objective of understanding the characteristics of a broader population, by sampling a subset of that population. The process of generalising from the sample to the broader population is subject to errors, including sampling error, due to selecting only part of the population; response bias, where the respondents are not representative of the population as a whole; and poor questionnaire design (McLellan 1999, 30-37).

Case-study research, on the other hand, is not based on statistical sampling of a population and requires a different type of generalisation. Case studies seek to identify theoretical propositions that can be generalised to a broader set of situations, to which they can logically be related (Niederkofler 1991; Eisenhardt and Graebner 2007; Swanborn 2010; Yin 2014). This approach is well described by Niederkofler as aiming to 'create and expand rich theoretical frameworks that should be useful in analysing similar cases' (1991, 239). Yin refers to analytic generalisation, which is intended 'to generalise to other concrete situations and not just contribute to abstract theory building' (2014). That said, the process of generalising from specific cases to apparently 'similar' situations is not straightforward. According to Swanborn (2010, 69), the factors to be considered in assessing whether the results of a case can be generalised to a broader domain include the consistency of the results in the case(s) studied; the internal validity of the study; the strength of the link between observations and suggested influences; the degree to which the phenomena of interest can be isolated from their context; the similarity of the sets of influencing forces between the case(s) and the broader domain, and the statements being generalised. These factors suggest that generalising the findings of a case study is not straightforward, but requires thoughtful analysis of both the case and the relevant domain.

Recognising the caveats associated with generalising the results of surveys and case studies, the research design included both methods. This was intended to utilise the different perspectives afforded by the survey and case-study methods, and thus enhance the ability to generalise the research findings.

4.5 Conclusions

The research design developed for the investigation integrates the research question, the components of WSUD practice, a survey and a series of case studies. This design established a clear link between the information gathered during the research and the research question.

The research design allowed for information to be obtained from different sources, including a survey and case studies, with the case studies providing information via document analysis and interviews. Further, both qualitative and quantitative information was collected during the survey and interviews. The use of different sources, and types, of information was intended to enhance the rigour of the research and the robustness of the findings.

The research design was also intended to support generalisation of the findings of the research beyond the specific phenomena that were investigated, to a broader set of circumstances.

While this chapter described the general design of the empirical research, more detailed information about the design of the survey and the case studies is provided in Chapter 5, which follows, and Chapter 6, respectively.

Chapter 5

SURVEY ABOUT THE INFLUENCE OF STATUTORY LAND USE PLANNING ON WSUD PRACTICES

5.1 Introduction

This Chapter describes the planning, implementation and results of a survey of participants from the government, water utility, private and research sectors, about the influence of statutory land use planning on WSUD practices[26]. The survey gathered evidence about hypotheses related to whether statutory land use planning materially influences the adoption of WSUD practices; the extent to which statutory land use planning (SLUP) controls that include specific quantitative targets encourage the adoption of WSUD practices, compared with controls that lack such targets; the extent to which SLUP encourages the adoption of WSUD practices at greenfield residential developments, compared with infill residential developments; and the influence of SLUP on the adoption of the components of WSUD practice identified in Chapter 2. The survey provided insights about the influence of SLUP systems in jurisdictions across Australia on WSUD practices. The survey complemented the case studies, which will be described in Chapters 6, 7 and 8. The case studies examined how SLUP influenced the adoption of WSUD practices at individual residential developments. Gathering evidence from the different perspectives provided by the survey and the case studies was intended to enhance the robustness of the research findings.

Section 5.2 describes how hypotheses related to the research question were identified. It also discusses the preparation of questions for the survey, designed to provide information about the validity of these hypotheses. This process linked the research question, the hypotheses and the survey questions.

Section 5.3 discusses the design and implementation of the survey, while section 5.4 presents and interprets the results.

[26] The survey described in this chapter was initially reported as Williams (2016).

The conclusions derived from the survey are set out in Section 5.5. This section also discusses the links between the survey described in this chapter and the case studies described in the following chapters.

5.2 The Research Question, Hypotheses and the Survey Questions

A survey is 'a system for collecting information' (Sue and Ritter 2007, 1), which should be clearly linked to the objectives of the research in respect of which the survey is undertaken (McLennan 1999, 1-4; Sue and Ritter 2007, 18-20). In the case of the research described in this thesis, the objective was to provide answers to the research question, which asks how SLUP influences WSUD practice. This section describes the identification of hypotheses linked to the research question and the preparation of survey questions, to examine the validity of these hypotheses. This approach ensured there was a clear connection between the survey and the research question.

The identification of these hypotheses will now be examined in some detail.

5.2.1 Hypothesis 1: The Influence of Statutory Land Use Planning on WSUD Practices

Chapter 3 reviewed literature about influences on the implementation of WSUD. On balance, the literature indicates that SLUP regimes can encourage the adoption of WSUD practices, despite some studies suggesting that overly complex, fragmented planning frameworks can discourage the implementation of WSUD. The following hypothesis reflects the proposition that SLUP encourages the adoption of WSUD practices:

> ***Statutory land use planning materially encourages the adoption of WSUD practices in residential developments***[27]

5.2.2 Hypothesis 2: The Influence of Statutory Land Use Planning Tools that Include Specific Quantitative Targets

An issue considered in Chapter 3 was the role of specific, quantitative targets in fostering the adoption of WSUD practices. One study discussed in Chapter 3 (Cooperative Research Centre for Water Sensitive Cities 2014a) indicated that there is tension between advocates of highly prescriptive tools and those favouring a more flexible approach. Notwithstanding this finding, the literature generally supports the view that

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[27] The hypotheses in this chapter relate to WSUD practices in residential development. Section 6.2.1 describes why the empirical research focused on residential development.

regulatory tools that include quantitative targets more strongly encourage the implementation of WSUD practices, compared with tools that lack such targets. The next hypothesis is consistent with this view:

> ***Statutory land use planning tools that include specific quantitative targets encourage the adoption of WSUD practices in residential developments to a greater extent than tools that do not include specific quantitative targets***

5.2.3 Hypothesis 3: The Influence of Statutory Land Use Planning at Greenfield Developments, Compared with Infill Developments

In the Australian context, residential development can be categorised as either greenfield development or infill development. Greenfield development is the conversion of non-urban land on the fringe of metropolitan areas to residential use (InfraPlan 2013). In contrast infill development is 'new development that occurs within established urban areas where the site or area is either vacant or has previously been used for another urban purpose' (Queensland. Department of Infrastructure and Planning 2009, 155; New South Wales. Department of Planning 2010, 272). The terms greenfield and infill are commonly used by the Australian land development industry (Urban Development Institute of Australia 2015).

A hypothesis can be advanced about the influence of SLUP on the implementation of WSUD practices at greenfield developments, compared with infill developments. Wong and Eadie (2000) suggest there are greater opportunities to employ planning tools such as zoning, land use controls and land capability assessments to encourage WSUD in relatively undeveloped catchments, compared with existing 'built up' areas. This conclusion suggests that SLUP is more likely to encourage WSUD practices at greenfield locations, compared with infill locations. However, further investigation of Wong and Eadie's proposition does not appear to have been carried out. Identifying the relative influence of SLUP frameworks in greenfield and infill developments would be relevant to the research question. The following hypothesis addresses this issue and is consistent with the view of Wong and Eadie (2000):

Statutory land use planning encourages the adoption of WSUD practices to a greater extent at greenfield residential developments, compared with infill residential developments

5.2.4 Hypothesis 4: The Influence of Statutory Land Use Planning on the Components of WSUD Practice

The identification of a number of specific components of WSUD practice was an integral part of the research. It was therefore highly desirable that a hypothesis specifically related to these components be examined in the survey. As noted in Chapter 2, some interpretations of WSUD concentrate on urban stormwater management and place less emphasis on the other components of WSUD practice. Section 3.3.3 similarly noted that some studies identify WSUD with urban stormwater management, while others identify WSUD with the urban water cycle as a whole, and the interaction of this cycle with urban design.

Thus, urban stormwater management is widely accepted as integral to WSUD, but this broad acceptance does not necessarily extend to the other components of WSUD, that is, the urban water cycle, urban water infrastructure and urban design components in Table 2-4. It is therefore plausible to suggest that SLUP tools may including more comprehensive requirements related to urban stormwater management, compared to the other components of WSUD practice. This reasoning leads to the following hypothesis:

Statutory land use planning encourages the implementation of the different components of WSUD practice identified in this research to different degrees in residential developments

This sub-section described how a hypothesis about the influence of SLUP on the components of WSUD practice identified in this research was developed. The next section discusses how the importance of these components, according to the participants, was examined in the survey.

5.2.5 The Importance of the Components of WSUD Practice

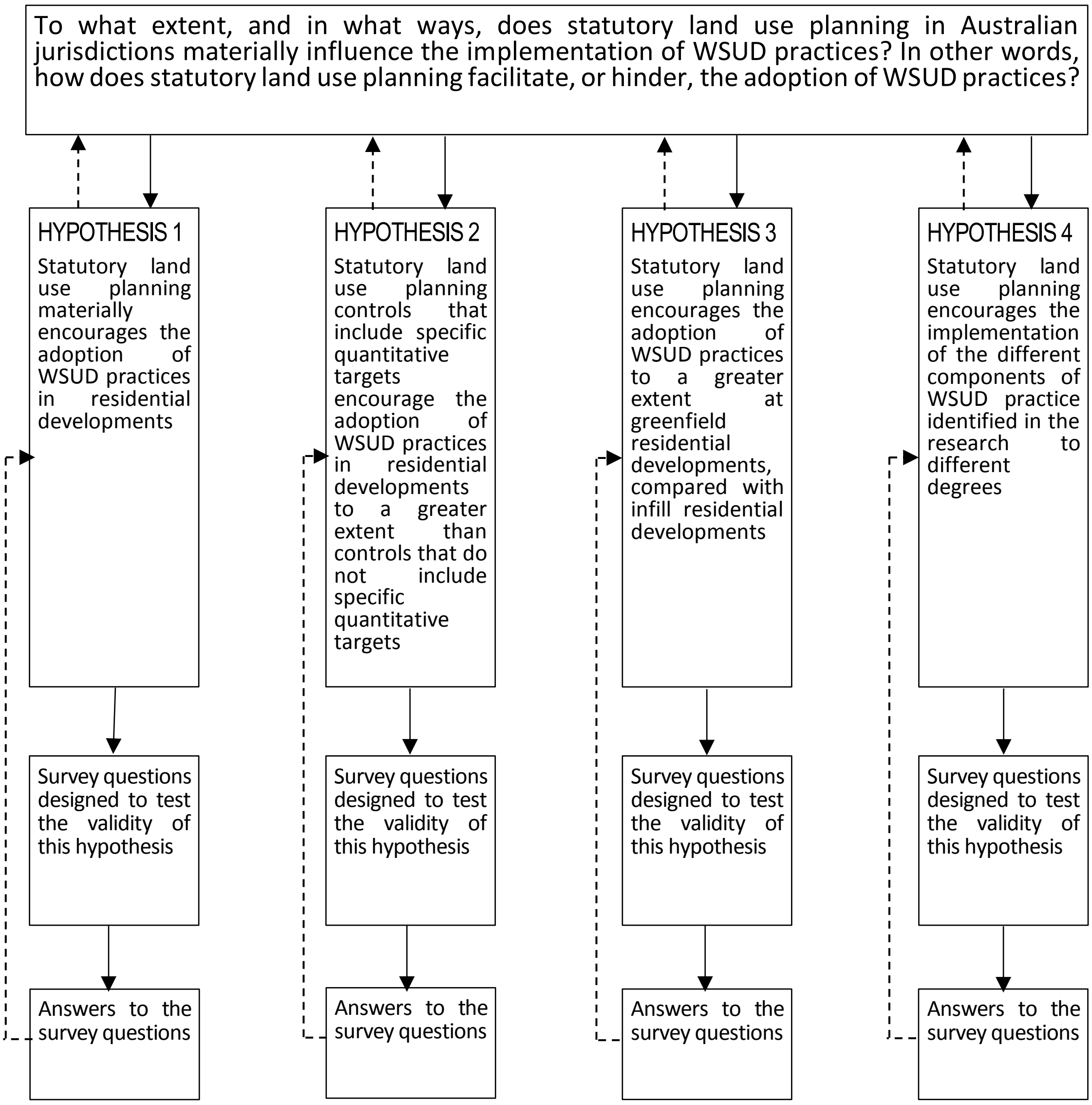
The survey included questions about the perceived importance of the components of WSUD practice identified in this thesis. The research design relied to a large degree on the components of WSUD practice shown in Table 2-4. Thus, for example, survey responses deeming all these components to be important would support the integrity of the research design. Conversely, responses stating that the components differ markedly in importance, or indicating that some components are unimportant, would suggest that the design is of limited value.

The next section shows how the hypotheses described in the preceding discussion are linked with the research question.

5.2.6 Aligning the Research Question, Hypotheses and the Survey Questions

The hypotheses outlined above relate to the influence of SLUP on WSUD practices, with each hypothesis examining a different aspect of this influence. Thus, examining the validity of the hypotheses would inform answers to the research question. The survey included questions related to each hypothesis. The relationship between the research question, the hypotheses and the survey questions is shown in Figure 5.1.

Figure 5-1: Relationship between the Research Question, Hypotheses and the Survey Questions



Source: original figure

The dotted lines in Figure 5.1 show how the answers to the survey questions provided information about each of the hypotheses and, ultimately, the research question. Table 5.1 lists the hypotheses and the corresponding questions in the survey.

Table 5-1: Hypotheses and the Survey Questions Related to Them

Hypothesis	Survey Questions Related to the Hypotheses
HYPOTHESIS 1: Statutory land use planning materially encourages the adoption of WSUD practices in residential developments	This question relates to the influence of statutory land use planning on the adoption of WSUD practices in residential developments. In your experience, how encouraging or discouraging is this influence? (rank on a scale from ***Strongly encouraging*** to ***Strongly discouraging***)
	Please comment about the reasons for your answer to the previous question. You can support your comments with examples.
HYPOTHESIS 2: Statutory land use planning tools that include specific quantitative targets encourage the adoption of WSUD practices in residential developments to a greater extent than tools that do not include specific quantitative targets	To what extent do statutory land use planning controls that include specific quantitative targets encourage the adoption of WSUD practices in residential developments, compared with controls that do not include specific quantitative targets? (rank on a scale from ***To a much larger extent*** to ***To a much smaller extent***)
	Please comment about the reasons for your answer to the previous question. You can support your comments with examples.
HYPOTHESIS 3: Statutory land use planning encourages the adoption of WSUD practices to a greater extent at greenfield residential developments, compared with infill residential developments	To what extent does statutory land use planning encourage the adoption of WSUD practices in greenfield residential developments, compared with infill residential developments? (rank on a scale from ***To a much larger extent*** to ***To a much smaller extent***)
	Please comment about the reasons for your answer to the previous question. You can support your comments with examples.
HYPOTHESIS 4: Statutory land use planning encourages the implementation of the different components of WSUD practice identified in this research to different degrees in residential developments	This question is about the influence of statutory land use planning on the adoption of components of WSUD practice in residential developments. In your experience, how encouraging or discouraging is this influence on each component listed below? (rank on a scale from ***Strongly encouraging*** to ***Strongly discouraging***
	Please comment about the reasons for your answer to the previous question. You can support your comments with examples
Instead of testing a specific hypothesis, these questions relate to the validity of the research design used in this thesis, which includes four distinct components of WSUD practice	In your opinion, how important is each component of WSUD practice listed below? (rank each component of WSUD practice on a scale from ***Very important*** to ***unimportant)***
	Please comment about the reasons for your answer to the previous question. You can support your comments with examples.

Source: original table

Figure 5.1 and Table 5.1 both demonstrate the logical connections between the survey and the research question.

To this point, the survey has been discussed in general terms. The following section describes the design and implementation of the survey in more detail.

5.3 Designing and Implementing the Survey

All surveys, including online surveys, include a number of steps (Sue and Ritter 2007, 2):

1. Defining objectives
2. Defining the population of interest and establishing a sampling frame
3. Designing a data collection strategy
4. Preparing a questionnaire
5. Collecting and managing data
6. Analysing and reporting the data.

These steps provide a convenient structure to discuss the planning and implementation of the survey, as shown in Table 5-2:

Table 5-2: Steps Taken to Plan and Implement the Survey

Step in the Survey Process	Implementation of the Step in the Survey
Define objectives	The objective of the survey was to gather information about a number of hypotheses related to the research question, as discussed in section 5.2.6 of this thesis.
Define the population and choose a sampling frame	The population selected was staff from organisations in Australia affiliated with the Cooperative Research Centre for Water Sensitive Cities (CRCWSC), who were accessible via the CRCWSC's email contact lists. The CRCWSC is a research group, designed to improve urban water management practices and encourage cities to become 'water sensitive', which in 2014 consisted of 79 organisations from the state government (13), local government (31), research (11) water utility (10), private (7), international (6) and community (1) sectors (Cooperative Research Centre for Water Sensitive Cities 2014b). The CRCWSC provided access to a diverse group of participants, with a shared interest in, and knowledge of, WSUD. The sampling frame consisted of the entire population, that is, an invitation to take part in the survey was distributed to the entire group available via the CRCWSC's email contact lists. Sue and Ritter describe this as saturation sampling, where an attempt is made to collect data from all members of the defined population (2007, 27).
Design a data collection strategy	Data was gathered by distributing an email with an invitation to take part in the survey, on an opt-in basis. Those recipients who wanted to participate completed an anonymous online questionnaire. The process of opting-in to an anonymous questionnaire maintained confidentiality and met the ethical requirements for the survey.[28] Online surveys are a suitable method when the sample is large and widely dispersed geographically (Sue and Ritter 2007, 5). These conditions applied in this case.
Develop a questionnaire	The questionnaire was designed to examine a series of hypotheses that relate to the research questions, as discussed in section 5.2.6. Demographic questions were also included in the questionnaire, which is attached as Appendix 1. Every effort was made to word the questions clearly and unambiguously, as emphasised by Sue and Ritter (2007, 38), and Fowler (2014, 79-81). Definitions of specific terms, related to WSUD and statutory land use planning, which were included in the questions, were provided to the respondents, as recommended by Fowler (2014, 80). The questionnaire included both rating-scale (quantitative) and open-ended (qualitative) questions. The rating-scale questions used a 5-point scale. The questions asked for qualities such as influence, extent and importance to be rated on a scale from 1 to 5. While debate

[28] The proposed ethics protocol for the survey was considered, and approved, by the Monash University Human Research Ethics Committee.

	about the merits of scales with more points continues, 'it is safe to say that 4 or 5 point scales will be serviceable for most attitude or opinion data collection' (Sue and Ritter 2007, 51). The scale questions did not use the 'agree-disagree' format, where respondents are asked to rate on a scale the degree to which they agree or disagree with a statement. Not using this format is consistent with Fowler's view (2014, 91) that 'Usually, researchers will have more reliable, valid and interpretable data if they avoid the agree-disagree question form'. Particular care was taken in the design of the rating scales to ensure they recognised the full range of possible responses in a balanced way, to avoid a potential source of bias (Brace 2008, 58). Thus: 1. The rating scale for questions about *influence* recognised that influence can be deemed to be either positive or negative and included responses ranging from strongly positive to strongly negative. 2. The rating scale for questions about *extent* and *importance* included responses ranging from very large/very important to very small/unimportant. Open-ended questions were included. A key reason for doing this was to obtain information about the reasons why respondents provided the ratings they did. While categorising and coding responses to open-ended questions can require considerable effort (McLellan 1999, 12; Sue and Ritter 2007, 44-47; De Vaus 2014, 148-152), they do provide opportunities for unanticipated information to be obtained (Sue and Ritter 2007, 44; Fowler 2014, 88). Given the scarcity of research about the influence of statutory land use planning on WSUD practices, it was deemed important to afford opportunities for respondents to provide their insights.
Collect data	An invitation to take part in the survey was distributed on 18 August 2015 to staff from organisations affiliated with the CRCWSC, who were accessible via the CRCWSC's email contact lists.[29] Data was collected via an anonymous online questionnaire.
Manage the data	Quantitative and qualitative data were recorded on a survey host managed by the CRCWSC. Data were transferred from this host to an Excel database. The quantitative information was also transferred to the SPSS[30] software package for statistical analysis.
Analyse the data	The analysis of the data is discussed in the following section.

Source: original table

[29] The invitation to take part in the survey was distributed via an email message from the Cooperative Research for Water Sensitive Cities (CRCWSC). The readership of messages of this type, at that time, was estimated to be in the range 810 – 950: email dated 6 August 2015 from Steve Pogonowski, CRCWSC Communications officer, copy on file with the author.

[30] SPSS refers to the software package Statistical Package for the Social Sciences®.

5.4 Results and Discussion

5.4.1 Introduction

Fifty one responses to the survey were received. Table 5-3, following, provides information about these responses.

Table 5-3: Information about the Responses to the Survey

Number of responses that answered all the rating-scale questions and included comments about all, or some, of the ratings	40
Number of responses that answered all the rating-scale questions and did not include comments about the ratings	6
Number of responses where the participant ceased answering the rating-scale questions part way through the questionnaire, and included comments about all, or some, of the ratings that were provided[31]	3
Number of responses where the participant ceased answering the rating-scale questions part way through the questionnaire and did not include comments about the ratings that were provided[31]	2
Total number of responses	51

The 51 responses correspond to a response rate in the range 5.4 – 6.3 percent. This is considered to be a reasonable response rate for the group invited to take part in the survey.[32]

Demographic information about the participants is shown in Table 5.4:

Table 5-4: Demographic Information about the Survey Participants

JURISDICTION								
Australian Capital Territory	New South Wales	Northern Territory	Queensland	South Australia	Tasmania	Victoria	Western Australia	No answer
3	4	0	5	1	0	20	13	5

LEVEL IN ORGANISATION[33]				
Executive	Senior/Middle Management	Supervisor/Team Leader	No Management Responsibility	No answer
6	17	8	15	5

EMPLOYMENT SECTOR[33]					
Private sector	Local Government	State Government	Water Utility/ Corporation	Research	No Answer
9	16	9	9	2	6

31 These responses did not answer all the rating-scale questions. However, no factors were identified to support the exclusion of the ratings that were supplied, or the accompanying comments (where provided), from the analysis of the results. Thus, for these responses, the ratings that were supplied, and the accompanying comments (where provided), were included in the analysis.

32 Personal communication from Steve Pogonowski, Communications Officer, Cooperative Research Centre for Water Sensitive Cities, 6 September 2015, on file with the author.

33 These categories are general headings used by the Cooperative Research Centre for Water Sensitive Cities (CRCWSC) for data analysis. They were used in this research, to facilitate the integration of the survey results with the CRCWSC's broader research program.

PROFESSIONAL TRAINING AND EXPERIENCE[33]							
Urban/ Land Use/ Statutory Planning	Engineering	Natural Resource Management	Science	Management Business Economics	Law	Urban Design Architecture Landscape Architect	No Answer
18	7	5	6	3	1	5	6

ROLE IN WATER CYCLE MANAGEMENT[33]				
Stormwater/ Waterways	Water Supply	Land Use Planning Urban Development	Total Water Cycle Management	No answer
10	2	22	11	6

YEARS OF PROFESSIONAL EXPERIENCE[33]					
Less Than 5 Years	5 Years to Less Than 10 Years	10 Years to Less Than 15 Years	15 Years to Less Than 20 Years	20 Years or More	No Answer
1	8	9	10	17	6

Source: original table

The information in Table 5.4 indicates that the respondents came from a range of jurisdictions, employment levels, employment sectors, training, professional role and professional experience. This diversity indicates a strong potential for the survey to provide a broad and deep set of insights into the influence of SLUP on WSUD practices in Australia.

The statistical tests applied to the quantitative information were carried out using the SPSS software package. The qualitative information was analysed manually, by an iterative process of reviewing the material, identifying patterns and themes, and progressively refining the emergent concepts (Bazeley 2007; Saldaña 2012). Manual analysis was feasible, as the comments that were provided to supplement the answers to the rating-scale questions typically did not extend beyond several sentences. The quantitative and qualitative information were both considered in the interpretation of the survey responses.

The responses to the survey questions are summarised and discussed below. The quantitative information is presented in tabular and graphical formats.

5.4.2 Influence of Statutory Land Use Planning on the Adoption of WSUD Practices

The survey included the question:

This question relates to the influence of statutory land use planning on the adoption of WSUD practices in residential developments. In your experience, how encouraging or discouraging is this influence?

The respondents were also asked to comment about their answers.

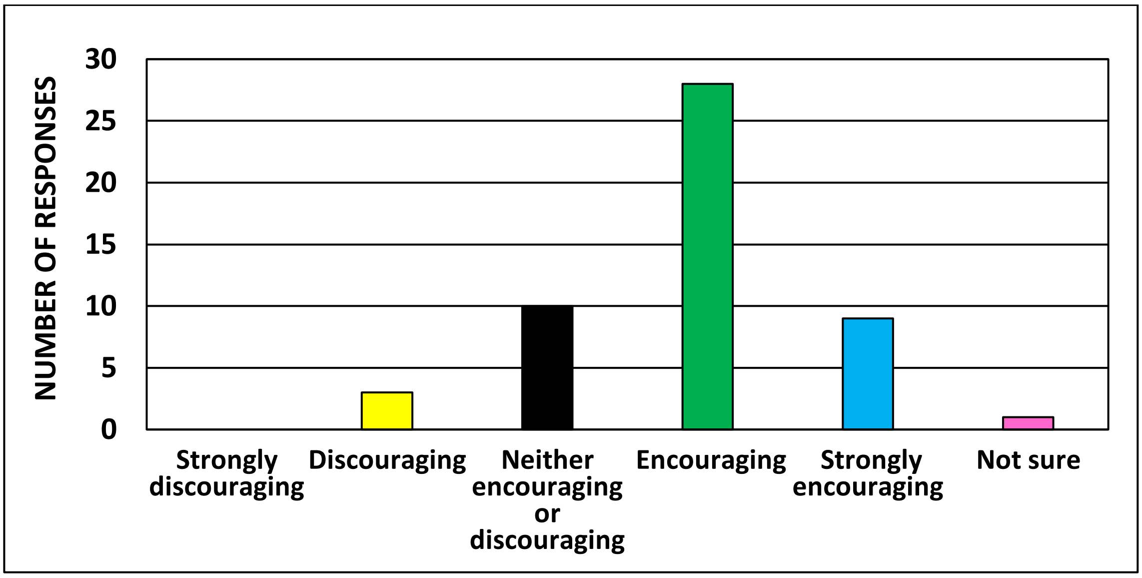
The answers to this question are summarised in Table 5-5 and Figure 5-2, which follow.

Table 5-5: Responses to Question about the Influence of Statutory Land Use Planning on WSUD Practices

Response	Number of responses
Strongly encouraging	9
Encouraging	28
Neither encouraging or discouraging	10
Discouraging	3
Strongly discouraging	0
Not sure	1

43 comments about this question were received, from the 51 participants who answered it

Figure 5-2: Responses to Question about the Influence of Statutory Land Use Planning on WSUD Practices



The quantitative results suggest that SLUP encourages the adoption of WSUD practices. From 51 responses, 37 were either *encouraging* or *very encouraging*, compared with only three *discouraging* responses and no *strongly discouraging* responses. The favourable influence of SLUP was generally attributed to it making the adoption of WSUD practices a legally binding obligation, as expressed by comments such as 'It encourages because it makes it a requirement' and 'In most cases, WSUD would not be incorporated into residential developments unless it was in the planning scheme…and enforced by Melbourne Water and local government'. That said, it is of interest that 13 respondents provided a *discouraging* or *neither encouraging or discouraging* rating. Comments linked these unfavourable or neutral ratings with two arguments. Firstly, a majority of the comments suggested that, while SLUP systems include requirements related to WSUD, corresponding implementation procedures, such as capacity building and enforcement measures, are lacking. Secondly, the remaining comments suggested that current SLUP regimes do not include sufficient requirements mandating the adoption of WSUD practices.

In summary, the quantitative and qualitative results from the survey strongly support the hypothesis that SLUP has a favourable influence on the adoption of WSUD practices.

5.4.3 Influence of Statutory Land Use Tools that Include Specific Quantitative Targets

The survey included the question:

To what extent do statutory land use planning controls that include specific quantitative targets encourage the adoption of WSUD practices in residential developments, compared with controls that do not include specific quantitative targets?

The respondents were also asked to comment about their answers.

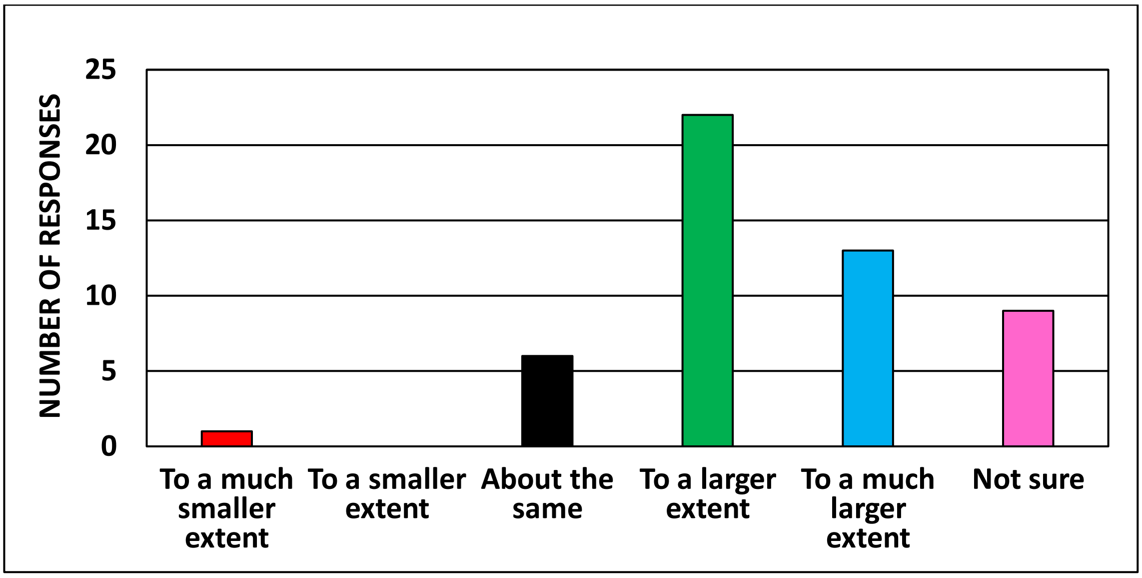
The answers to this question are summarised in Table 5-6 and Figure 5-3:

Table 5-6: Responses to Question about Extent to Which Statutory Land Use Planning Controls with Specific Quantitative Targets Influence WSUD Practices, Compared with Controls Without Targets

Response	Number of responses
To a much larger extent	13
To a larger extent	22
About the same	6
To a smaller extent	0
To a much smaller extent	1
Not sure	9

35 comments about this question were received, from the 51 participants who answered it

Figure 5-3: Responses to Question about Extent to Which Statutory Land Use Planning Controls with Specific Quantitative Targets Influence WSUD Practices, Compared with Controls without Targets



The ratings provided by the respondents strongly support the idea that statutory land use controls with specific quantitative targets influence WSUD practices to a greater extent than controls that lack such targets. The total of 35 *much larger extent* and *larger extent* responses contrasts sharply with the single *much smaller extent* answer. The comments consistently suggested that quantitative targets provide clear, unambiguous direction to all participants. This view was well summarised by the remark of one participant that: 'Quantitative controls are easier to administer by all parties as they know where the goal posts are and they can aim for them accordingly. In short, it removes subjectivity and uncertainty for all parties involved in statutory planning'. Several comments contrasted the clarity provided by quantitative targets with a perceived lack of guidance provided by less prescriptive controls, typified by the remark that 'Wishy washy policy guidelines are too open to different interpretations, legal appeals and are not effective'. This point was further reinforced by a comparison with other areas of statutory planning: 'A comparative example is building/solar orientation in residential development. It is difficult to 'push' and advocate for proper building orientation as there is not a quantitative target/standard for building/solar orientation'. There were nine *Not sure* responses. The comments that accompanied these responses indicated that the respondents had little experience with quantitative targets. Overall then, the quantitative and qualitative evidence from the survey consistently supports the hypothesis that SLUP controls, which include specific quantitative targets, encourage the adoption of WSUD practices to a larger extent than controls lacking such targets.

The findings of the survey are consistent with the findings of a number of authors, who suggest that specific, quantitative targets are essential elements of the regulatory framework for WSUD (Taylor and Weber 2004; Kay et al. 2004; Chandler and Eadie 2006; Mouritz and Shepherd 2006; Potter and RossRakesh 2007; Corbett 2012, 2959; Tjandraatmadja et al. 2014, 81). Approaches using broader, non-quantitative objectives were not supported by the respondents to the survey. According to the survey, specific quantitative targets should be included in SLUP tools intended to foster the adoption of WSUD practices.

5.4.4 Influence of Statutory Land Use Planning at Greenfield Developments, Compared with Infill Developments

The survey included the following question:

To what extent does statutory land use planning encourage the adoption of WSUD practices in greenfield residential developments, compared with infill residential developments?

The respondents were also asked to comment about their answers.

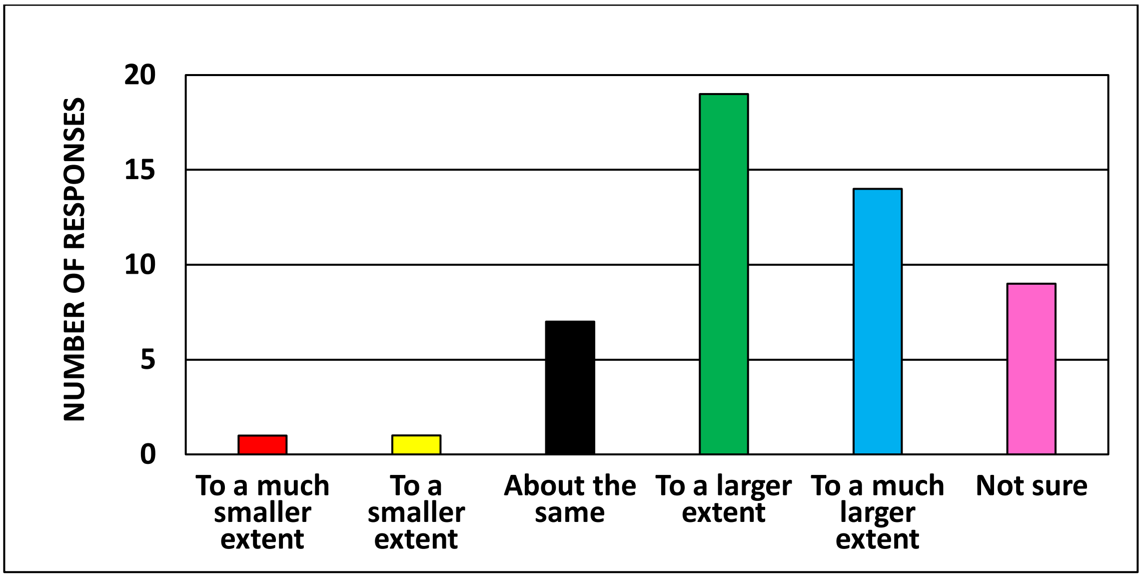
The answers to this question are summarised in Table 5-7 and Figure 5-4.

Table 5-7: Responses to Question about the Extent to which Statutory Land Use Planning Encourages the Adoption of WSUD Practices in Greenfield Developments, Compared with Infill Developments

Response	Number of responses
To a much larger extent	14
To a larger extent	19
About the same	7
To a smaller extent	1
To a much smaller extent	1
Not sure	9

37 comments about this question were received, from the 51 participants who answered it

Figure 5-4: Responses to Question about the Extent to which Statutory Land Use Planning Encourages the Adoption of WSUD Practices in Greenfield Developments, Compared with Infill Developments



The ratings provided by the respondents support the idea that SLUP encourages WSUD practices to a greater extent at greenfield developments, compared with infill developments: there were 33 *larger extent* and *much larger extent* responses, compared with a total of only two *smaller extent* and *much smaller extent* responses, and seven neutral, *About the same*, responses.

Comments suggested that the greater capacity of SLUP to encourage WSUD practices in the greenfield setting, identified by most respondents, can largely be attributed to two causes. Firstly, it was stated that SLUP requirements related to WSUD, which must be adopted at greenfield developments, may not apply to typically smaller-scale infill developments. Examples of such requirements were reported to include Clause 56.07 of the Victoria Planning Provisions and Western Australia's *Better Urban Water Management* policy (Western Australia. Western Australian Planning Commission 2008a). In Victoria, Clause 56.07 includes requirements designed to encourage the adoption of WSUD practices. The clause applies to the subdivision of land to create residential lots, the typical pathway for greenfield development, but does not apply to, for example, the construction of two or more dwellings on a single lot, a process by which infill development can occur. Similarly, *Better Urban Water Management* in Western Australia provides a framework that supports the implementation of WSUD. It generally applies to greenfield development, but not infill development, 'unless significant water management issues are present' (Western Australia. Western Australian Planning Commission 2008a, vii). Secondly, infill sites may be subject to physical constraints, such as limited space and existing infrastructure, which restrict the ability to install WSUD measures, whereas greenfield sites have 'the ability to accommodate measures on a clean slate without the encumbrances of existing conditions', as one participant put it. These factors are not mutually exclusive and many comments cited both. The *Not sure* responses were usually linked with the respondent having worked exclusively in either greenfield settings, or infill settings, and not being able to compare them.

The quantitative and qualitative responses are consistent and support the hypothesis that SLUP encourages WSUD practices to a greater extent at greenfield developments, compared with infill developments.

The survey provides evidence about the comparative effectiveness of SLUP in the greenfield and infill environments, which has not been provided by previous studies. The findings also have implications for efforts to enhance the adoption of WSUD practices at infill sites. Potential changes to SLUP controls, designed to ensure that WSUD requirements for infill developments are similar to those for greenfield developments, should be considered. The technical constraints on installing WSUD infrastructure at infill sites should also be examined, to identify ways to overcome them.

5.4.5 Influence of Statutory Land Use Planning on the Components of WSUD Practice

The survey included the following question:

This question is about the influence of statutory land use planning on the adoption of components of WSUD practice in residential developments. In your experience, how encouraging or discouraging is this influence on each component listed below?

The respondents were also asked to comment about their answers.

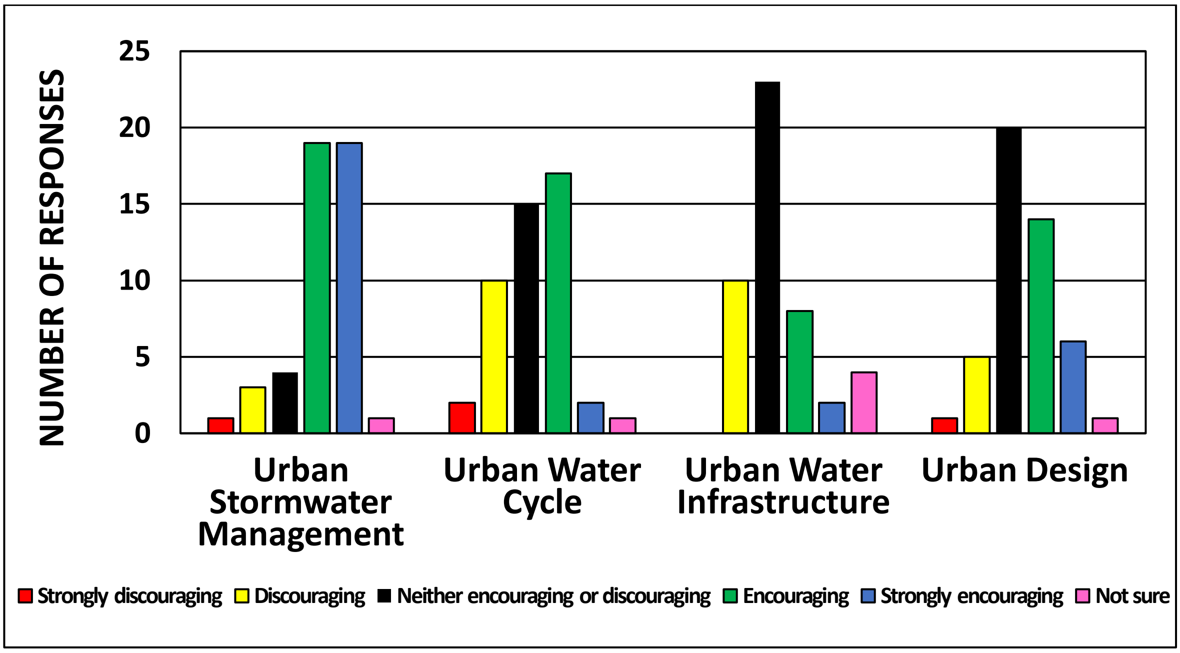
The answers to this question are summarised in Table 5-8 and Figure 5-5.

Table 5-8: Responses to Question about the Influence of Statutory Land Use Planning on Components of WSUD Practice

Component	Strongly discouraging	Discouraging	Neither Encouraging or Discouraging	Encouraging	Strongly encouraging	Not sure	No answer
Urban stormwater management	1	3	4	19	19	1	4
Urban water cycle	2	10	15	17	2	1	4
Urban water infrastructure	0	10	23	8	2	4	4
Urban design	1	5	20	14	6	1	4

28 comments about this question were received, from the 47 participants who answered it

Figure 5-5: Responses to Question about the Influence of Statutory Land Use Planning on the Components of WSUD Practice[34]



The ratings indicate that, according to the respondents, the urban stormwater management component is most influenced by SLUP, with all the other components being less influenced. There appear to be differences between the ratings for the other components, although these are less distinct than the clear differences between the stormwater management component and the others.

[34] As Table 5.8 indicates, four respondents did not complete the question about the influence of statutory land use planning on the components of WSUD practice. These 'no answer' responses were not included in Figure 5.5, to improve its ease of interpretation.

A statistical analysis of the results in Table 5.8 was carried out, using the Wilcoxon signed ranks test[35]. This analysis indicates that the higher ratings for the stormwater management component differ from the ratings for the other components, at both the 5% and 1% levels of significance. The findings, summarised in Table 5.9[36], also shows that the higher ratings for the urban design component, compared with the ratings for the urban water infrastructure component, differ at the 5% significance level. The other differences are not statistically significant.

Table 5-9: Comparisons of Ratings for the Influence of Statutory Land Use Planning on the Components of WSUD Practice, via the Wilcoxon Signed Ranks Test

Comparison Between Ratings for the Following Components	z Value	p Value
Urban stormwater management and urban water cycle	-4.582	0.000
Urban stormwater management and urban water infrastructure	-4.549	0.000
Urban stormwater management and urban design	-4.011	0.000
Urban water cycle and urban water infrastructure	-0.636	0.524
Urban water cycle and urban design	-1.736	0.083
Urban water infrastructure and urban design	-2.276	0.023

[35] Six pairs can be formed from the components of WSUD practice, as shown in Table 5.9. The ratings of the components in each of these pairs were compared by the following procedure:

1. The ratings were coded thus: Strongly discouraging = 1, Discouraging = 2, Neither encouraging or discouraging = 3, Encouraging = 4, Strongly encouraging = 5. 'Not sure' responses were not included in the analysis.
2. The coded ratings were compared in SPSS via the 2-tailed Wilcoxon signed ranks test.

For a description of the Wilcoxon signed ranks test see, for example, Wilcoxon (1945), Randles (1988), and Rey and Neuhauser (2011). The survey ratings were provided by the same respondents and hence the comparisons involve paired, not independent results. The Wilcoxon signed ranks test is a non-parametric test, suitable for paired results in ordinal scale format, which are not assumed to be normally distributed (McCrum-Gardner 2008). When the Wilcoxon signed ranks test is used to compare paired results, the null hypothesis is that the set of pairwise differences has a probability distribution centred at zero, corresponding to there being no difference between the two sets of results. The alternative hypothesis is that the two sets of results do differ (Woolson 1998).

That said, the use of this test to compare results from rating scales has been debated. For example, (Svensson 2001) argues that it should not be used to compare rating-scale data, whereas its use for this purpose is supported by other researchers (Nanna and Sawilowsky 1998, Vaughn et al. 1999). Given the use of the Wilcoxon signed ranks test by a number of scholars to analyse rating-scale data, this test was used to analyse the quantitative results from the survey. This allowed an analytical procedure to be used to supplement the descriptive statistics. In any case, conclusions were drawn from the rating-scale responses by considering both descriptive statistics and the results of the Wilcoxon signed ranks test.

[36] The z scores in Table 5.9 are expressed as standard deviations and are derived from the test statistic calculated in the Wilcoxon signed ranks test. For a description of the derivation of z values for the Wilcoxon signed ranks test, see Field (2009, 552-554). The z score is used to determine the probability value, p, which is: 'The likelihood that a statistical result would have been obtained by chance…alone' (Vogt and Johnson 2011, 305). Thus, p values less than 0.05 indicate there is less than a 5 percent likelihood that the differences between the sets of ratings being compared were due to chance and p values less than 0.01 indicate there is less than a 1 percent likelihood that the differences between the sets of ratings being compared were due to chance.

In a general sense, the ratings suggest that SLUP has the greatest influence on the urban stormwater management component and a lesser influence on the other components, with the degrees of influence on the latter group not differing greatly.

The comments consistently suggested that most SLUP requirements, which relate to WSUD practices, concern urban stormwater management. In contrast, there were reported to be comparatively few SLUP requirements about the other components of WSUD practice. This view was summarised by the comments from participants that 'Current requirements…is for water quantity and quality only and does not encourage the other outcomes' and 'There is little enablement of alternative urban water practices through the statutory planning process'.

If SLUP requirements mainly relate to the urban stormwater management component, as indicated by the respondents, this would be expected to result in a relatively stronger influence on that component. This stronger influence was evident in the ratings. The qualitative and quantitative information both point to SLUP having a greater influence on stormwater management, compared with the other components of WSUD practice. This finding supports the hypothesis that SLUP influences the different components of WSUD practice to different degrees.

These results provide an understanding of the limitations of current Australian SLUP systems. The comments from the participants indicate that the statutory requirements in these systems concentrate on influencing urban stormwater management and do not adequately consider the other components of WSUD practice. This narrow focus is consistent with the reported higher level of influence on urban stormwater management practices, compared with the other components. According to the survey respondents, the broad concept of WSUD, encompassing the entire urban water cycle and strongly linking water management and urban design, is not manifest in either current SLUP requirements, or their influence on WSUD practices.

5.4.6 Importance of the Components of WSUD Practice

The survey included the following question:

In your opinion, how important is each component of WSUD practice listed below?

The respondents were also asked to comment about their answers.

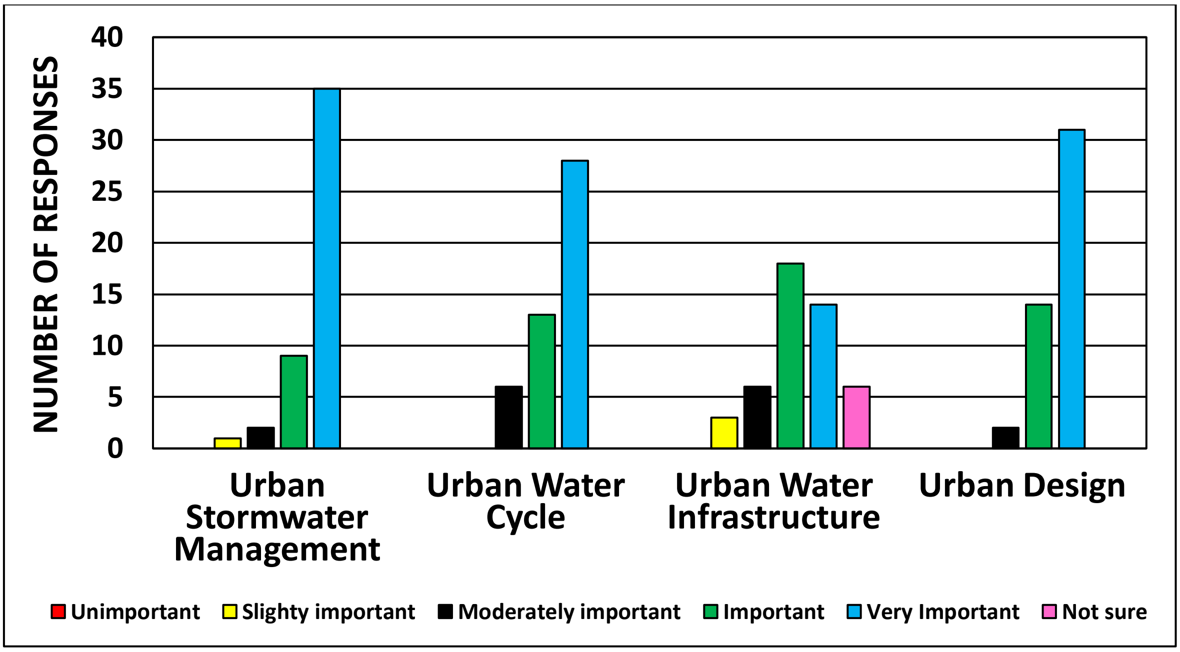
The answers to this question are summarised in Table 5-10 and Figure 5-6.

Table 5-10: Responses to Question about the Importance of Components of WSUD Practice

Component	Unimportant	Slightly Important	Moderately Important	Important	Very Important	Not sure	No answer
Urban stormwater management	0	1	2	9	35	0	4
Urban water cycle	0	0	6	13	28	0	4
Urban water infrastructure	0	3	6	18	14	6	4
Urban design	0	0	2	14	31	0	4

23 comments about this question were received, from the 47 participants who answered it

Figure 5-6: Responses to Question about the Importance of Components of WSUD Practice[37]



To clarify the importance that the respondents attributed to each component of WSUD practice, the totals for the *very important* and *important* responses were compared with the totals for the *unimportant*, *slightly important* and *moderately important* responses, for each component. The results are shown in Table 5-11, following:

[37] As Table 5.10 indicates, four respondents did not complete the question about the importance of the components of WSUD practice. These 'no answer' responses were not included in Figure 5.6, to improve its ease of interpretation.

Table 5-11: Analysis of Responses to Question about the Importance of the Components of WSUD Practice

Component of WSUD Practice	Total of the *very important* and *important* responses	Total of the *unimportant, slightly important and moderately important* responses
Urban stormwater management	44	3
Urban water cycle	41	6
Urban water infrastructure	32	9
Urban design	45	2

Essentially, the respondents identified the urban stormwater management, urban water cycle and urban design components as highly important components of WSUD practice, with urban water infrastructure being rated slightly less highly. There were also six *not sure* responses for the infrastructure component. That said, the urban water infrastructure component was, overall, rated as important.

Statistically, the ratings for the urban water infrastructure component differ from the ratings for the other components, at both the 5% and 1% levels of significance. There were no significant differences between the ratings for the urban stormwater management, urban water cycle and urban design components, at these levels of significance, as indicated in Table 5.12[38].

Table 5-12: Comparisons between the Ratings for the Importance of Components of WSUD Practice, via the Wilcoxon Signed Ranks Test

Comparison Between Ratings for the Following Components	z Value	p Value
Urban stormwater management and urban water cycle	-1.583	0.113
Urban stormwater management and urban water infrastructure	-3.191	0.001
Urban stormwater management and urban design	-0.475	0.635
Urban water cycle and urban water infrastructure	-2.773	0.006
Urban water cycle and urban design	-1.334	0.182
Urban water infrastructure and urban design	-3.451	0.001

[38] The results were analysed using the Wilcoxon signed ranks test, in the same way that the results for the influence of statutory land use planning on the components of WSUD practice were analysed (refer to footnote 35). The responses to the question about the importance of the components of WSUD practice were coded as follows:
Unimportant = 1, Slightly important = 2, Moderately important = 3, Important = 4, Very important = 5. 'Not sure' responses were not included in the analysis.

The importance of all components was supported by comments[39] such as 'All of the above help us…respond to a range of current challenges therefore are very important'. The comments from respondents who rated the importance of the urban water infrastructure component less highly than the other components typically suggested that the appropriate combination of centralised and decentralised systems should be determined by the outcomes being sought and does not have to be regulated. This view was summarised by the comment that 'the greatest emphasis should be on achieving good outcomes, rather than prescribing whether they're achieved by centralised or decentralised systems'. The evidence from the survey indicates that all the components of WSUD practice are important, with the infrastructure component being ranked of slightly lesser importance than the others.

The results of the survey have implications for the research design used in this thesis, which includes four distinct components of WSUD practice. The participants confirmed that, to them, these components are all important elements of WSUD practice, notwithstanding the infrastructure component being ranked less highly than the others. If the survey had shown very large differences in the importance of the components, or had identified some components as relatively unimportant, then re-evaluation of the design would have been necessary. This situation did not arise and the results of the survey support the validity of the research design.

5.5 Conclusions

This chapter described the planning, implementation and results of a survey of participants from a range of sectors, which examined the influence of SLUP on WSUD practices. The survey examined four hypotheses related to the research question. The participants in the survey were recruited from a range of jurisdictions, employment levels, employment sectors, training, professional role and professional experience, ensuring that the survey was informed by a wide range of views.

[39] Forty seven respondents provided ratings in response to this question, whereas 23 provided comments. This was the lowest number of comments received for any question. It is acknowledged that it becomes more difficult to correlate the quantitative and qualitative responses, as the proportion of respondents who provide comments decreases. That said, the information provided by the ratings and the comments appeared to be consistent for this, and all the other, questions.

The survey examined the importance, to the participants, of the components of WSUD practice identified in the research. The participants rated all the components as highly important, with the infrastructure component being rated somewhat less highly than the others. This recognition of the components as important shows they provide a sound basis for the research design.

The survey indicates that SLUP does favourably influence the implementation of WSUD practices, by making their adoption a legally binding requirement. While a minority of participants rated the influence of SLUP as neutral or unfavourable, these ratings do not appear to be linked to a rejection of the capacity of statutory planning to influence WSUD practices, but instead reflect views that supporting implementation measures are lacking, or that appropriate statutory requirements are not currently in place. Taken as a whole, the survey strongly supports the idea that SLUP encourages the implementation of WSUD practices.

According to the participants, SLUP controls, which include specific quantitative targets, more strongly encourage the adoption of WSUD practices, compared with controls lacking them. This is consistent with previous findings that specific, quantitative targets are essential elements of the regulatory framework for WSUD. The survey did not support the alternative view that a less prescriptive approach should be used, to encourage innovation and flexibility.

While the survey did indicate that SLUP encourages the adoption of WSUD practices, it also identified factors that limit the influence of current SLUP frameworks. One limitation is that SLUP provides less encouragement at infill sites, compared with greenfield sites. The survey suggested two reasons for this difference. Some SLUP tools include thresholds related to physical scale, which typically are exceeded by greenfield developments, but not smaller-scale infill developments. There are also technical constraints that can limit the installation of WSUD infrastructure at infill sites, which do not apply to greenfield sites. With state governments having set targets for infill development for Australia's major cities, which range from around 50 percent of total urban development to 70 percent (Newton et al. 2012, 482), ensuring that SLUP can effectively promote WSUD practices at infill sites is important. A further limitation of current SLUP systems was identified, associated with the influence of these systems on different components of WSUD practice. The survey indicated that SLUP has a markedly greater influence on the urban stormwater management component, compared with the other three components. This finding was reinforced by the participants' statements that SLUP requirements mainly relate to urban stormwater management, with a corresponding lack of requirements related to the other components. The survey indicates that current Australian SLUP frameworks do not adequately recognise WSUD as a concept that encompasses the whole urban water cycle and strongly links water management and urban design. The survey provided fresh insights into the limitations of current SLUP systems, associated with their lesser influence at infill sites, compared with greenfield sites, and their restricted focus on urban stormwater management. These limitations should be considered in reforms of SLUP systems.

The survey provides broad insights, at the level of SLUP systems as a whole. As discussed in Chapter 4, the empirical research undertaken for this thesis also included a series of case studies, which examined how SLUP affected the implementation of WSUD practices at four residential developments. The survey and the case studies provide information about SLUP systems as a whole, and about specific developments, respectively. The case studies also provide an understanding of how SLUP influenced WSUD practices over time. Thus, the case studies provided a different, complementary perspective from that of the survey.

The case-study investigation is discussed in the next three chapters. The detailed design of the case studies is reported in Chapter 6. Chapter 7 describes two case studies in the state of Victoria and Chapter 8 describes two case studies in the state of Western Australia. Chapter 9 integrates the findings of the survey and the case studies.

Chapter 6

DESIGN OF THE CASE STUDIES

6.1 Introduction

This Chapter includes detailed information about the design of the case studies, to supplement that already provided in Chapter 4. This includes the selection of the cases, units of analysis used in the cases, and the collection and analysis of information.

Following this introduction, section 6.2 discusses how a protocol to select cases was developed and specific cases were selected, in accordance with it. Section 6.3 describes how the components of WSUD practice were used as units of analysis in the case studies. Section 6.4 describes how information about the case studies was obtained from documents and interviews with key actors, and how the information was analysed. Some concluding remarks are set out in Section 6.5.

6.2 Selection of the Case Studies

6.2.1 Definition of a Case Study

The starting point in the selection of the cases was to define a case, for the purposes of the research: this was consistent with Yin's advice about the need to carefully define the case(s) being examined (2012, 6). For this research, cases were drawn from residential developments, based on the following considerations:

1. Investigating WSUD practices in a single type of land use would avoid the potential uncontrolled variability associated with studying the implementation of WSUD in a range of different land uses. In other words, as Eisenhardt puts it, (1989, 537) 'selection of an appropriate population controls extraneous variables and helps to define the limits for generalising the findings'.
2. As noted in section 3.2, WSUD practices appear to have been implemented more extensively in residential developments in Australia, compared with other types of land uses, such as industrial, commercial and institutional.

A case study was therefore defined as:

> ***An investigation of how statutory land use planning influenced WSUD practices, when a parcel of land, not previously used for residential purposes, was developed for residential use.***

It was also determined that cases should be selected from mainstream, commercially driven residential developments, which had not received subsidies from external sources, such as governments or research organisations. Selecting commercial developments was intended to avoid the possibility that the implementation of WSUD practices had been affected by financial arrangements with external parties, making the influence of SLUP harder to discern.

The definition meant that cases examined situations where land had been 'developed' for residential use. In the Australian SLUP context, this means that statutory planning approval had been gained for land to be subdivided[40] for residential use. In Australia, subdivision of land for residential purposes typically is the final step in a SLUP process, and is conditional on SLUP approval.

This approach therefore focused the case studies on development at the residential subdivision scale, rather than being confined to the role of SLUP at a larger neighbourhood or precinct scale. Four arguments supported this focus:

1. Important SLUP tools are applied at the residential subdivision stage of the planning process. For example, in the Victoria Planning Provisions, Clause 56.07, Integrated Water Management, is part of Clause 56, Residential Subdivision, meaning that urban water management is considered at the residential subdivision stage. In Western Australia, as well, state government guidance states that WSUD should be considered at the subdivision stage of the land use planning process (Western Australia. Western Australian Planning Commission 2008a, 7).

[40] 'Subdivision' refers to creating smaller lots from a larger parcel of land, with the smaller lots having separate legal titles. Subdivision allows lots to be created, which can be sold and developed, within the constraints provided by SLUP. Also refer to footnote 18.

2. The residential subdivision stage is the point at which key decisions about the components of WSUD practice identified in Chapter 2 (that is, urban stormwater management, the urban water cycle, urban water infrastructure and urban design) are made. The influence of SLUP on the components of WSUD used to frame the research could not be properly discerned, without considering the subdivision stage.
3. The implementation of the broad vision of WSUD advocated by, for example, Mouritz (1996) and the *Urban stormwater best practice environmental management guidelines* (Victoria. Stormwater Committee 1999), relies on changes to conventional practices related to housing layout, road layout, and streetscape layout and design. Each of these aspects is finalised during the subdivision process.
4. According to Gardiner (2007), the implementation of WSUD in Australia has centred on the inclusion of large-scale stormwater drainage infrastructure in public open space networks. However, preliminary discussions with land developers and staff from local and state governments, and a review of the 'grey literature'[41], suggested that Gardiner's conclusion is no longer correct, as evidenced by the adoption of decentralised WSUD practices within individual residential subdivisions. This suggests that investigating the possible role of SLUP in fostering such practices could provide useful insights.

The following discussion describes how, firstly, a protocol was developed to select cases (section 6.2.2) and, secondly, cases were selected in accordance with this protocol (section 6.2.3).

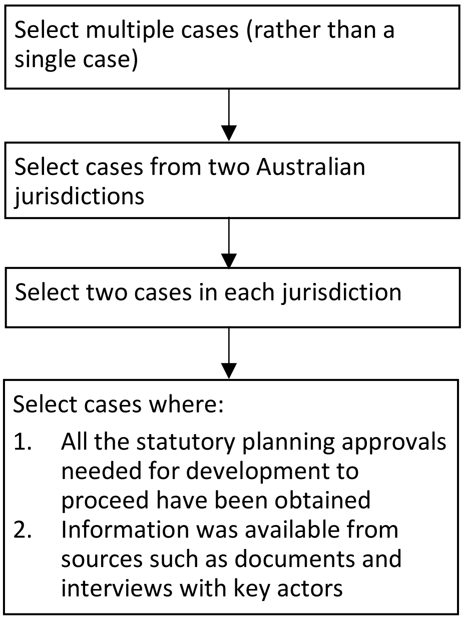
6.2.2 Protocol to Select Cases

This sub-section describes the development of a protocol to select cases. The protocol is shown schematically in Figure 6.1 and the rationale for each the individual steps in the

[41] A widely accepted definition of grey literature is 'that which is produced on all levels of governmental, academics, business and industry in print and electronic formats, but which is not controlled by commercial publishers' (Hopewell et al. 2007, 2). It may include a range of unpublished information, such as government policy documents, commercial reports, unpublished data and personal communications.

protocol is discussed after this figure. Consistent with the definition of a case study, the cases were drawn from residential developments.

Figure 6-1: Protocol to Select Cases



Source: original figure

Select Multiple Cases

A fundamental decision in a case study investigation is whether to examine a single case, or a number of cases. A single case can typically be studied in greater detail than multiple cases but, generally, multiple-case designs are preferred over single cases (Rowley 2002, 21; Yin 2014, 63-64). Multiple cases reduce the risks associated with relying on a single, potentially unrepresentative, case and are significantly more likely to provide insightful analyses (Yin 2014, 64). In the present study, it would be difficult to justify making generalisations about Australian statutory planning frameworks from a single case. Therefore, multiple cases were investigated.

Select Cases in Two Australian Jurisdictions

Cases could have been selected from a single Australia jurisdiction, or from more than one jurisdiction. Selecting cases from one jurisdiction only would have illustrated the influence of a single statutory planning framework on WSUD practices. This could introduce the same type of risks associated with relying on a single case study identified by Yin (2014, 64). In contrast, selecting cases in more than one jurisdiction would allow the influence of more than one statutory planning framework to be examined. This approach was adopted.

The next step was to determine the number of jurisdictions from which cases should be selected. This decision had to recognise the tension between increasing the number of jurisdictions, to increase the robustness of the findings, and the resources available for the research. The decision was taken to investigate cases from Victoria and Western Australia. Material differences in the statutory planning environments for WSUD in these states were noted in the qualitative responses to the survey of Australian water resource managers, land use planners and researchers described in the previous chapter. In particular, specific mandatory targets were reported to be a more important part of the SLUP system in Victoria, compared with Western Australia. These reported differences between the statutory planning systems in these jurisdictions suggested that useful insights could be obtained by examining cases in Victoria and cases in Western Australia.

Select Two Cases in Each Jurisdiction

Having determined to investigate cases from two jurisdictions, a procedure to select the cases within each jurisdiction was required. In the case-study method, cases should be selected using theoretical considerations, instead of by statistical sampling intended to provide information about the population from which samples are drawn (Eisenhardt 1989; Flyvbjerg 2006; Eisenhardt and Graebner 2007; Small 2009; Yin 2014). The objective of this 'theoretical sampling' is to identify cases which strongly elucidate the phenomenon under investigation: 'cases are selected because they are particularly suitable for illustrating and extending relationships and logic among constructs' (Eisenhardt and Graebnar 2007, 27).

According to Yin (2014), a range of sampling techniques has been proposed, including using particularly important cases, using pairs of contrasting 'polar' cases[42], selecting cases expected to produce similar results and selecting cases expected to produce different results. The use of polar examples has been advocated in research using

[42] The term 'polar cases' is used to describe cases that differ greatly in their level of performance, or their success in achieving their stated objectives. This contrast may make trends more observable. See Eisenhardt (1989, 537) and Eisenhardt and Graebner (2007, 27).

multiple cases by a number of scholars (Eisenhardt 1989; Pettigrew 1990; Eisenhardt and Graebnar 2007).

Unequivocal examples of cases deemed to be particularly important were not identified in discussions with staff from local and state governments, and a review of the 'grey literature'. However, in Victoria, cases with apparently differing levels of implementation of WSUD practices could be identified. The selection of paired cases, including more comprehensive and less comprehensive implementation of WSUD practices, would resemble the polar sampling advocated by Eisenhardt (1989), Pettigrew (1990) and Eisenhardt and Graebnar (2007). Therefore, the approach of selecting two cases, including more and less comprehensive implementation of WSUD practices, was adopted in Victoria. In contrast with Victoria, there was less divergence in the implementation of WSUD practices in the potential case studies examined in Western Australia. This, in itself, is useful empirical information. Two case studies were selected in Western Australia to, firstly, balance the number of Victorian cases and, secondly, to provide the opportunity to identify reasons for the greater degree of convergence in that jurisdiction, compared with the Victorian cases.

The procedure described above meant that two cases from Victoria and two cases from Western Australia were investigated. This allowed both intra and inter jurisdictional comparison of cases.

Selecting Cases Where Planning Approval had been Obtained and Information was Available

When selecting cases, it was also considered necessary to ensure that the statutory planning approval process had been completed. This would allow the influence of SLUP on WSUD practices throughout the entire statutory approval process to be investigated. At a practical level, it was important that information about the cases was readily available, from documents, interviews with key actors and site inspections.

Having developed a protocol to select cases, potential cases needed to be identified and specific cases selected in accordance with the protocol. The next section describes this process.

6.2.3 Selecting the Case Studies

As discussed earlier in section 3.2, comprehensive, coherent information about the implementation of WSUD practices in Australia cities is currently lacking. Given this situation, information about potential cases was derived from a number of sources:

1. Searches of the websites of land development companies, local governments and state government planning departments.
2. Searches of the websites of organisations that promote sustainable urban water management practices, such as Clearwater, based in Victoria (Clearwater n.d.) and New WAter Ways, based in Western Australia (New WAter Ways 2017). These websites list urban developments said to include extensive WSUD measures.
3. Advice from a range of urban water management and land use planning practitioners from local government, state government and private industry.
4. The grey literature related to urban development and sustainable urban water management practices in Australia.

After reviewing the information from these sources, cases were selected in accordance with the protocol shown in Figure 6-1. The cases are shown in Table 6-1:

Table 6-1: Case Studies Selected for Investigation

Jurisdiction	Case Studies
Victoria	Coburg Hill, Melbourne
	Davis Road East, Tarneit, Melbourne
Western Australia	Lane Gardens, Bletchley Park, Perth
	Wungong Precinct E, Stages 3, 4 and 5, Perth

Source: original table

A major factor that favoured the selection of the cases in Table 6.1 was that, for them, a reasonable number of participants were available for interview. In Australia, the complete residential development process, starting with rezoning of land for residential purposes and culminating in physical construction of dwellings and associated services, can take several years. Indeed, the case studies reported in this thesis demonstrate this. Several potential case studies were excluded because the developments commenced prior to 2010 and sufficient numbers of key participants could not be located.

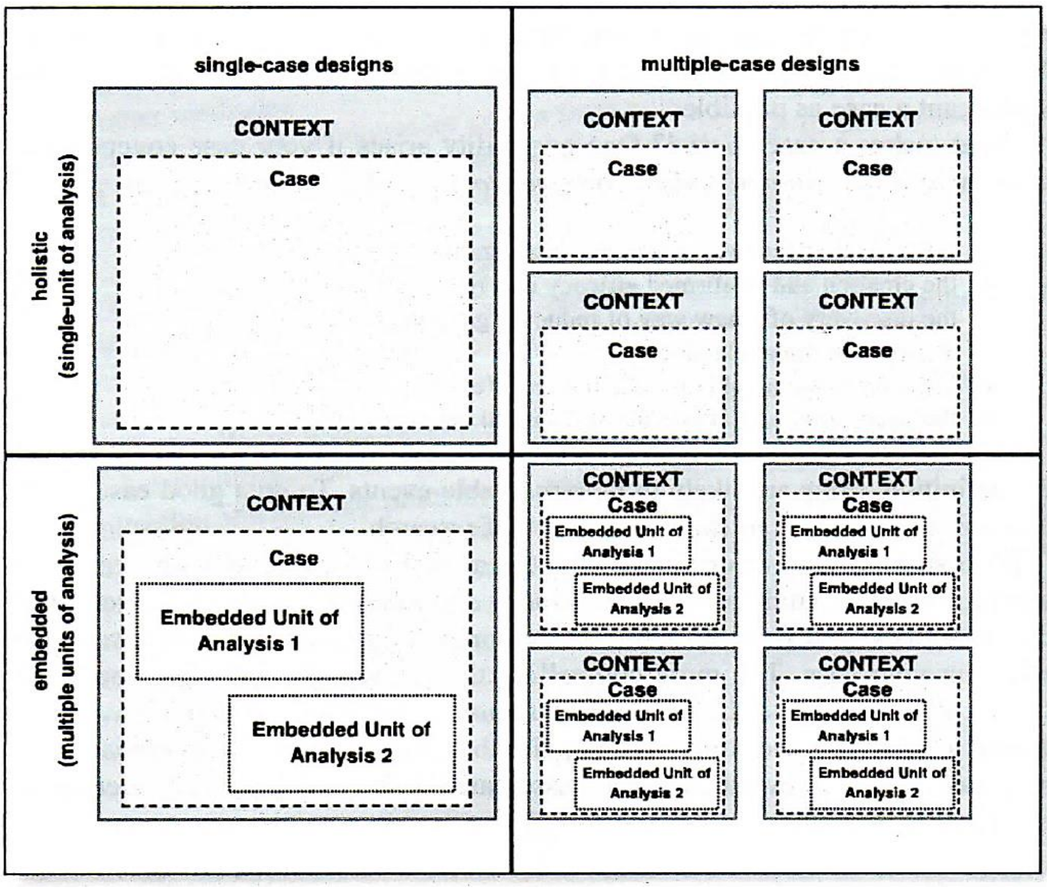
The next section describes how the case study design used the components of WSUD practice as 'units of analysis'.

6.3 Units of Analysis

As well as the number of cases, a further dimension that a case study design can consider is whether each case will be considered as a whole, or whether it will include embedded subcases. Subcases are units of analysis that consider a particular aspect of the broader case (Rowley 2002, 22; Baxter and Jack 2008, 550; Yin 2012, 7-8). Using subcases increases the opportunities to analyse information and can provide better understanding of cases (Baxter and Jack 2008, 550).

In the current study, the components of WSUD were used as units of analysis. The case-study design can thus be described as a multiple-case design, with multiple embedded units of analysis. Yin identifies this as one of four basic case-study designs, as shown in the bottom right-hand quadrant in Figure 6-2:

Figure 6-2: Designs for Case Studies



Source: Yin (2012, 8)

Having identified the number of cases and the embedded units of analysis, the collection and analysis of information needs to be considered.

6.4 Collection and Analysis of Information

This section describes how information about the case studies was collected and analysed. Yin (2012, 10) suggests that sources of information for case studies commonly include:

1. Direct observations
2. Interviews
3. Archival records
4. Documents
5. Participant observation
6. Physical artefacts.

Information was obtained via three of the sources identified by Yin. The four residential developments just shown in Table 6.1 were physically inspected, which could be classified as direct observation. This provided an understanding of the sites in a general sense, which helped to place information from other sources in context, and also provided direct knowledge about how urban water infrastructure affected urban form and amenity. While the inspections provided some data, the primary sources of information were documents and semi-structured interviews. The collection and analysis of information from these sources is described in section 6.4.1 and section 6.4.2, respectively. That said, not all of Yin's sources were applicable to the current research. Archival records, in Yin's (2012, 12) sense of stored information retained by public or private agencies, were not a significant source of data. Neither participant observation or the collection of physical artefacts was used in the research.

6.4.1 Information from Documents

Identifying documents related to the cases

The first step in obtaining information about the case studies was to locate documents that:

1. Included information about the SLUP tools for each case

2. Were available in the public domain.

Documents were identified through discussions with urban water resource management and land use planning practitioners from local and state governments, and the private sector, as well as internet searches. These documents provided a preliminary understanding of the cases and assisted the preparation of scripts for the semi-structured interviews, which reflected the circumstances specific to each case.

During the interviews, informants were asked to provide, or to identify, further documents to supplement those previously located. This usually resulted in further documents being identified. At the conclusion of this process, in each case, a substantial set of documents had been compiled. These included specific SLUP tools such as statutory policies, planning schemes, development approvals and management plans prepared in accordance with conditions in SLUP tools. These documents provided a substantial amount of information about the SLUP regime for each case[43].

Analysing information from documents

As well as providing an initial overview of the cases, the documents were analysed to identify conditions in SLUP tools that may have influenced WSUD practices by the procedure shown in Figure 6-3:

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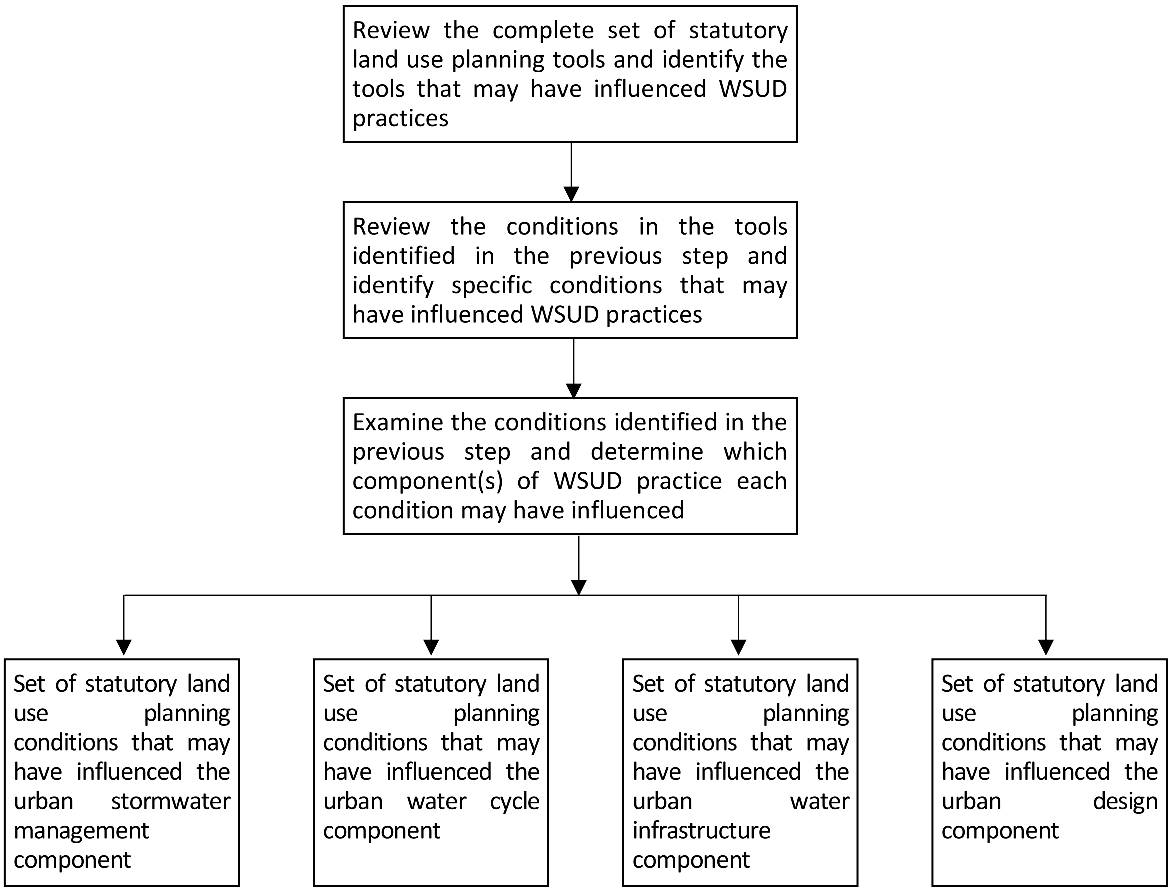
[43] The documents reviewed during the case studies are listed in Appendix 3. Collectively, these documents include several thousand pages.

Figure 6-3: Document Analysis Procedure



Source: original figure

As indicated by Figure 6.3, the first step in the procedure was to review the SLUP tools for each case and identify those tools that may have influenced the implementation of WSUD practices. The conditions in the statutory planning tools thus identified were examined, to identify specific conditions that may have influenced WSUD practices. The conditions identified by this process were then reviewed, to determine the component, or components, of WSUD practice each condition may have influenced. This procedure identified sets of SLUP conditions that may have influenced each component of WSUD practice[44].

[44] For example, the review of the statutory land use planning tools for a case study might identify the development approval, issued by the local council, as a statutory planning tool likely to influence WSUD practices. This approval would include a number of conditions, which would be reviewed to identify the specific conditions that may have affected WSUD practices. The specific conditions so identified would be examined, to determine which component, or components, of WSUD practice they may have influenced.

6.4.2 Information from Semi-structured Interviews

Obtaining information from semi-structured interviews

Interviews with key actors were an important source of information about the case studies. The subject matter could reasonably be described as complex, not clearly bounded and likely to produce a diverse range of opinions and comments. In these circumstances, the semi-structured interview, which has a 'flexible and fluid structure…usually organized around an aide memoire or interview guide' (Mason 2013, 1021-1022), is a suitable technique to employ (Miles and Huberman 1994, 17).

The use of semi-structured interviews required a script to be prepared. The interviews were intended to provide insights about how SLUP influenced both the adoption of WSUD practices generally, and the adoption of the components of WSUD practice identified in this research. Thus, an interview script was prepared, which included questions about:

1. The influence of SLUP on the adoption of WSUD practices generally, and the adoption of the components of WSUD practice
2. Whether there were features of the SLUP regime that enhanced its ability to influence the adoption of WSUD practices generally, and the adoption of the components of WSUD practice.
3. Whether there were features of the SLUP regime that hindered its ability to influence the adoption of WSUD practices generally, and the adoption of the components of WSUD practice.

The script also provided opportunities for interviewees to provide additional comments or explanations. It is attached as Appendix 2.

As the interview script indicates, notwithstanding the inclusion of some rating-scale, quantitative questions, the interviews relied heavily on qualitative questions. As Kvale (1994) discusses, a number of objections to qualitative research interviews have been raised, claiming that such interviews are 'not scientific, not objective, not trustworthy, not reliable, not intersubjective, not a formalized method, not hypothesis testing, not quantitative, not generalisable, and not valid' (1994, 1). Kvale suggests that these criticisms reflect a narrow view, which does not perceive the capacity of qualitative research to provide new knowledge and insights, which is not available by other means. Kvale also suggests that these criticisms can be used to improve the rigor of qualitative research.

While supporting the value of qualitative research interviews, Kvale does acknowledge that 'There is…a definite need…for methodological stringency' (1994, 148). Advice on preparing for, and carrying out, qualitative research interviews is provided by various sources, such as Weiss (1995), King and Horrocks (2010) and Turner (2010). Consistent with Turner's advice, the interview script was pilot tested with participants with relevant professional backgrounds, and the wording of questions was clear, neutral and open ended.

The selection of interviewees was a very important step. The literature discussed in Chapter 3 of this thesis and the grey literature suggested that interviewees should be recruited from several distinct groups. This would provide a comprehensive and diverse range of views about the case studies. These groups included:

1. Local government
2. State government
3. Land developers, who apply for SLUP approvals and are responsible for complying with approval conditions
4. Consultants engaged by developers to provide technical advice about urban water management infrastructure and compliance with statutory planning approvals
5. For the Victorian cases, Melbourne Water, which influences the design of stormwater drainage infrastructure.

It was preferable that representatives from each of these groups be interviewed, to provide the widest possible range of perspectives about the relationship between SLUP and WSUD practices. That said, the responsibility for planning and designing residential developments compliant with SLUP requirements largely rests with consultants. Thus, particular efforts were made to interview representatives of this group.

Having identified key participants to interview, potential interviewees were identified via corporate websites and professional networks. These individuals were invited to take part in the research. After the interviews had commenced, the recruitment process was continued, by asking participants to nominate further possible interview candidates. This was an example of the snowball sampling approach which 'uses a small pool of initial informants to nominate other participants who meet the eligibility criteria for a study' (Morgan 2013, 816-817). While the snowball technique is non-probabilistic (Small 2009; Morgan 2013), it did provide access to participants who had been directly engaged with the case studies. A total of 33 interviews were carried out with 30 interviewees. The distribution of interviews across the four case studies is shown in Table 6-2. The diverse range of perspectives from different groups is also shown in this table.

Table 6-2: Numbers of Interviews for the Case-Studies[45]

Group	Coburg Hill, Melbourne, Victoria	Davis Road East, Melbourne, Victoria	Lane Gardens, Bletchley Park, Perth, Western Australia	Wungong Precinct E, Stages 3, 4 and 5 Perth, Western Australia
Local government	2	1	2	1
State government	1	3	2	2
Developers	1	1	1	1
Consultants	3	3[46]	3[47]	3[48]
Melbourne Water	1	2	(*Not applicable*)	(*Not applicable*)
Total number of interviews	8	10	8	7
Total number of interviewees	8	9	7	6

Source: original table

A question that arises with snowball sampling is when the recruitment of interview subjects should cease. It has been suggested that subjects should be recruited until data saturation is reached (Small 2009; Francis et al. 2010), this being the stage when further

[45] A number of potential interviewees were approached, but declined to participate, as follows: Coburg Hill: one; Davis Road East: one; Lane Gardens: two; Wungong Precinct E, Stages 3,4 and 5: four. At Wungong Precinct E, Stages 3, 4 and 5, a further potential interviewee had retired and could not be contacted. Particular efforts were made to secure the participation of the Metropolitan Redevelopment Authority for the Wungong Precinct E, Stages 3,4 and 5 case, in view of the Authority's combined roles as a statutory planning authority and developer in this case, but such participation was not obtained.

[46] One of the consultants in this case was interviewed twice, that is, two consultants participated, providing a total of three interviews.

[47] One of the consultants in this case was interviewed twice, that is, two consultants participated, providing a total of three interviews.

[48] One of the consultants in this case was interviewed twice, that is, two consultants participated, providing a total of three interviews.

interviews do not provide further theoretical insights. It is considered that, for each case, the number of interviewees, and their varied professional roles, provided a sufficient degree of data saturation.

An additional consideration is that the interviews were not the only source of information for the case studies. The findings of the interviews were used in conjunction with the information provided by the document analysis.

As with any research involving human subjects, ethics approach was essential. An ethics protocol tailored to this study was prepared, endorsed[49] and implemented. For example, when comments from earlier subjects were put to interviewees to seek their reaction, in accordance with case-study practice (Swanborn 2010, 22), the sources of the prior comments were not identified; published comments from interviews have not been attributed to individuals; and protocols for information storage and analysis were observed.

The interviews were arranged at times convenient for the participants. The interviews for the Victorian cases were carried out face to face, but the interviews for the Western Australian cases were carried out by telephone. As recommended by Turner (2010), an introductory phase was used to clarify the interview process and resolve any concerns before the interview proper commenced. Interviewees were, at times, invited to respond to comments from earlier participants, in order to seek a better understanding of why the same phenomenon was viewed differently by different actors. The interviews were typically 45 to 60 minutes in duration. The interviews were digitally recorded, after which they were transcribed. The only exceptions to this were two Western Australian interviews, when the interviewees did not wish to be recorded. In these instances, comprehensive notes were taken during the interviews. In accordance with the ethics approval, copies of the transcripts (or the notes taken during the two interviews that were not recorded) were provided to the interviewees, who were invited to review them and to amend them, if they so desired. The atmosphere during the

[49] The semi-structured interviews were the subject of an application to the Monash University Human Research Ethics Committee (MUHREC), for ethics approval. This application was separate to that for the survey discussed in Chapter 5. The MUHREC approved the application related to the semi-structured interviews.

interviews was generally very constructive, and most subjects appreciated both the need for the research and the opportunity to contribute to it.

Analysing information from semi-structured interviews

The information from the semi-structured interviews was collated and analysed, with the assistance of the NVivo software package.[50]

The initial step in the analysis was to code the interview transcripts. Codes have been variously defined, for example, as a representation of an object or phenomenon (Strauss and Corbin 1998), a device used to identify themes in a text (Ryan and Bernard 2003) and as a word or phrase that captures the essence of a portion of text, or other data (Saldaña 2012). The underlying idea is that codes are used systematically to label specific elements of the information used in the research, which can then be subject to further analysis.

Codes can be derived either directly from the data, or from theoretical approaches developed prior to the analysis commencing (Strauss and Corbin 1998; Bazeley 2007, 76-77). The approach taken in this research was to review the interview transcripts and to determine the initial codes, based on this review. After assigning codes to specific text fragments in the interview transcripts, the analysis continued by comparing the coded information and seeking to identify consistent themes or patterns, which were progressively aggregated to 'reflect either overarching ideas or higher order concepts, or to identify broader, more complex themes running through the data' (Bazeley 2007, 100). This process was greatly assisted by the processing power and flexibility of the NVivo package.

While four cases were examined in the research, each case was analysed separately, before broader generalisation across the set of cases was attempted. This provided a detailed understanding of the richness and complexity of each case, after which wider patterns that applied across the complete set of cases were sought, as recommended by Eisenhardt (1989 and Huberman and Miles (2002). Reynaers (2014) used this

[50] NVivo is a proprietary software package supplied by the firm QSR International. The version used in this study was NVivo10 for Windows.

approach in her investigation of how public private partnerships influenced public values, in four case studies.

As well as the qualitative information discussed above, the interviews also provided quantitative information. During the interviews, the participants were asked to rate the influence of SLUP on the adoption of WSUD practices generally, and on the components of WSUD practice, using a rating scale. Collecting both qualitative and quantitative information recognised that case-study research can use a wide range of information, which can be either qualitative, quantitative, or a combination of both (Eisenhardt 1989; Yin 2014; Creswell 2014).

6.4.3 Combined Analysis of Information from Documents and Semi-Structured Interviews

Information about the case studies was gathered from documents and semi-structured interviews, as discussed in sections 6.4.1 and 6.4.2, respectively. As noted in section 4.3, the findings of case studies are regarded as more robust and nuanced when information from a range of sources is used (Rowley 2002, 23; Yin 2012, 13). Potential findings were derived, and tested, using information from both the document analysis and the semi-structured interviews. Proposed findings that were consistent with the evidence from both sources were regarded as more reliable than findings that lacked such consistency.

6.5 Conclusions

The design of the case study element of the empirical research included a protocol to select the cases, units of analysis and procedures to collect and analyse information. Four cases were selected in accordance with the protocol. These consisted of a pair of cases from Victoria and a pair of cases from Western Australia. Each case utilised the components of WSUD practice as embedded units of analysis. The design thus included multiple cases, with multiple units of analysis in each case. Information about the cases was primarily sourced from document analysis and semi-structured interviews, supplemented by inspection of the sites.

Taken as a whole, the case study research included divergent cases, which included varying levels of WSUD practices; cases from two Australian jurisdictions, which have different SLUP requirements for WSUD; multiple embedded units of analysis in each case; and sourced information from documents and interviews. This range of cases, units of analysis and sources of information enhanced the reliability of the findings and increased the ability to identify new insights about the nexus between Australian SLUP systems and WSUD practice.

This chapter described the design of the case studies in some detail. Chapter 7, which follows, describes the two case studies from the state of Victoria. The Western Australian cases are then discussed in Chapter 8.

Chapter 7

VICTORIAN CASE STUDIES

7.1 Introduction

This chapter describes two case studies located in Melbourne, the capital of the state of Victoria. In accordance with the procedure outlined in the previous chapter, one case includes a more comprehensive set of WSUD practices than the other.

The case studies were designed to examine how SLUP influenced the implementation of WSUD practices, including how SLUP influenced the components of WSUD practice identified in this thesis. Such detailed empirical analysis is lacking in previous studies.

Section 7.2, following, provides the statutory context for the case studies. This section outlines the SLUP system in Victoria, focusing on requirements particularly relevant to the implementation of WSUD practices. Section 7.3 and section 7.4 describe the two cases, including their physical settings, findings and conclusions. Section 7.5 then draws conclusions about the influence of the Victorian SLUP system on the adoption of WSUD practices, based on the results of the two cases. This section also compares the results of the case studies with the findings of the survey described in Chapter 5.

7.2 The Victorian Statutory Land Use Planning System[51]

The primary, or enabling, land use planning legislation in Victoria is the *Planning and Environment Act 1987* (Vic) ('the PEA'). The objectives of the PEA include the fair, orderly, economic and sustainable use and development of land[52]. The PEA establishes Victoria's land use planning framework. This framework incorporates statutory tools that regulate the use[53] and development[54] of land, including planning schemes[55] and planning permits[56].

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[51] This description of Victoria's statutory land use planning system draws on Eccles and Bryant (2011) and Victoria. Auditor General (2008).
[52] PEA s 4(1)(a).
[53] The PEA states that *use* 'in relation to land includes use or proposed use for the purpose for which the land has been or is being or may be developed' (s 3(1)). More simply, use refers to using land for a specific purpose.
[54] In the PEA, *development* includes the construction, demolition or removal of buildings; carrying out works; subdivision or consolidation of land; and placing buildings or works on land (PEA s 3(1)).
[55] Planning schemes are made under part 2 of the PEA.
[56] Procedures relating to permits are set out in part 4 of the PEA.

Planning schemes establish the land use planning framework in each local government area. Schemes must be prepared in accordance with the Victoria Planning Provisions. These Provisions provide a standardised format, which ensures that the structure of planning schemes is consistent across the state. Planning schemes incorporate state and local government policies, and a range of planning tools, including zones and overlays. Zones are a critical element of planning schemes, as they define the land uses that are allowed or prohibited in each zone and, if a land use is allowed, whether it requires a permit. Zones, which are shown on maps, cover the entirety of each local government area. Planning schemes require amendment from time to time, to reflect new policy settings, the outcomes of reviews, or proposed changes to land use. Amendments are usually prepared by the local council, but may be prepared by the Minister for Planning, another Minister, or a public authority authorised by the Minister for Planning. Planning scheme amendments are approved by the Minister for Planning[57]. Planning schemes are developed, and amended, by 'planning authorities'[58]. As well as zoning requirements, an overlay may apply to an area. Overlays typically regulate how land can be developed and relate to a single issue, such as heritage or flooding[59].

Planning schemes provide three results for proposed changes to land use:

1. A change of use may be allowed without a permit, usually subject to conditions in the relevant planning scheme being met.
2. A change of use may be allowed, subject to the issue of a permit. This is a very common way to change land use.
3. A change may be prohibited.

A planning permit is a legal tool that allows a change in land use, or the development of, a specific area of land, usually subject to a number of conditions. The assessment of permit applications, and the conditions included in permits that are issued, must be

[57] PEA s 35.
[58] PEA s 12.
[59] Overlays apply controls to a specific location, in addition to the requirements that apply to a zone. The location is indicated by a plan showing where the overlay applies. Overlays relate to specific issues, such as heritage, vegetation management, or restricting development in flood-prone areas. They may include schedules of conditions. The Victoria Planning Provisions includes a standard set of overlays. Overlays are discussed further in Victoria. Auditor General (2008, 27).

consistent with the planning scheme[60]. Permit applications are considered by the 'responsible authority', usually, but not always, the local council (Victoria. Auditor General 2008, 17).

In summary, the PEA provides a SLUP framework that establishes permitted and prohibited land uses in Victoria, and procedures to regulate proposed changes to land use.

7.3 Case Study: Coburg Hill, Melbourne

This section describes the first Victorian case study, which includes a more comprehensive set of WSUD practices than the second Victorian example. The case examined how SLUP influenced the adoption of WSUD practices at a residential development at Coburg Hill, Melbourne. Section 7.3.1 describes the development. Section 7.3.2 sets out the findings of the case study, and section 7.3.3 identifies conclusions drawn from the findings.

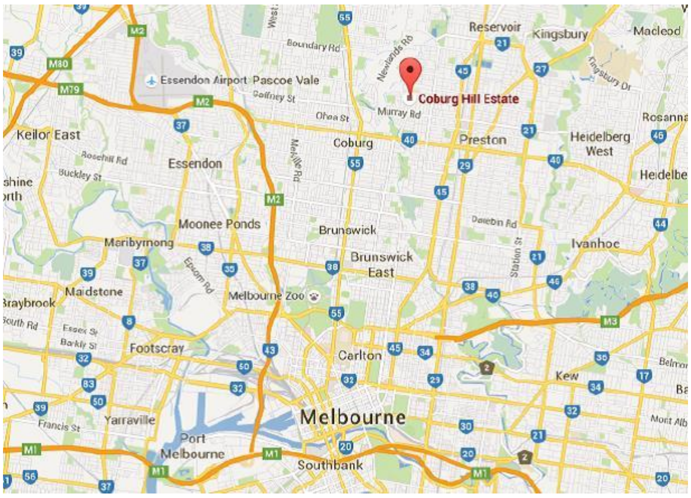
7.3.1 Description of the Coburg Hill Development

Physical Setting

Coburg Hill is a residential development located on a former industrial site in the Melbourne suburb of Coburg. The site is nine kilometres north of Melbourne's Central Business District and is located in the local government area administered by the Moreland City Council, as shown in Figure 7-1:

[60] PEA s 60(1) specifies that responsible authorities must consider a number of matters when assessing permit applications, including the relevant planning scheme. PEA s 62(1)(a) states that, in deciding to grant a permit, the responsible authority must include any condition that the planning scheme requires to be included.

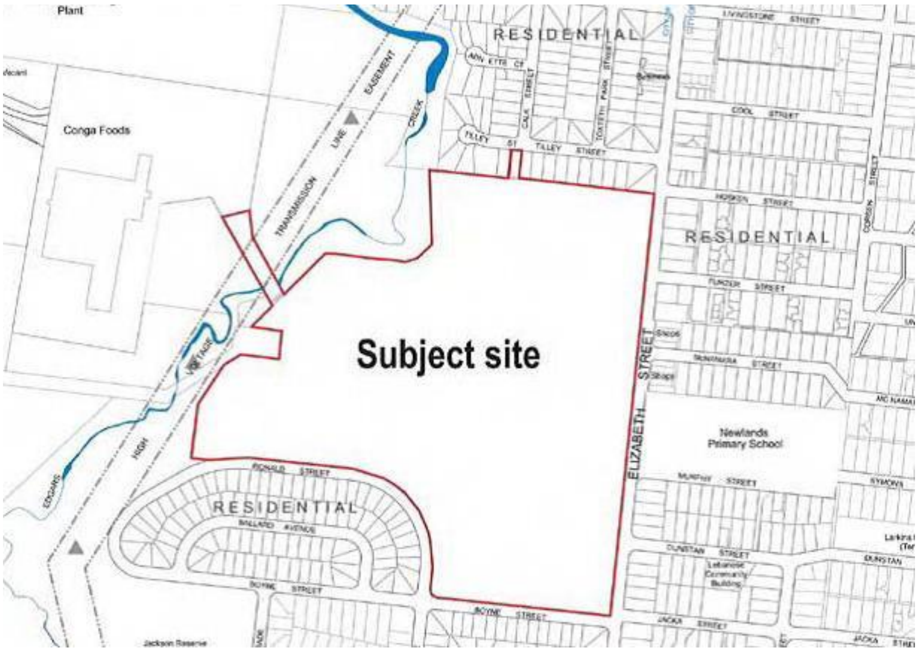
Figure 7-1: Location of the Coburg Hill Development[61]



Source: map data ©2016 Google

The site occupies an area of 20.54 hectares and is bordered by established residential development to the north, east and south, and Edgars Creek to the west, as shown in Figure 7-2:

Figure 7-2: Coburg Hill Development, Site Plan



Source: Collie Pty Ltd 2012, 3.

Coburg Hill includes two distinct catchments, one with an area of around 9 hectares, which flows into Moreland City Council's stormwater drainage system in Elizabeth Street

[61] In Figure 7-1 and all other location and site plans in this thesis, north is located at the top of the plan.

and another, with an area of around 11 hectares, which flows to Edgars Creek (Neil M Craigie Pty Ltd 2009, 2).

Change of Land Use to Residential

Prior to its development for residential use, the Coburg Hill site was used for industrial purposes. The site was purchased by Kodak in 1943 and used for many years to manufacture photographic products (Thomson 2010, 3). However, with the rise of digital photography, demand for the site's products declined and manufacturing ceased in 2004 (Thomson 2010, 3). Kodak subsequently sold the land, which was rezoned for residential use by the Minister for Planning in 2009. Rezonings are typically carried out by the local council but, in this case, the Minister for Planning intervened to expedite the statutory processes associated with the rezoning[62]. As an interviewee noted, 'the state government was very keen to do what they could to assist with avoiding the global financial crisis, so part of that was to get shovel-ready projects…that were being caught at a planning stage, expedited. So this is one of those, Coburg Hill…That all worked quite well' (interviewee H).

Coburg Hill is an example of an infill development, where new residential development has taken place in an established urban area. The development proceeded in a series of discrete stages. A planning permit was required for each stage, before development of that stage could commence. The construction of the first stage commenced in 2011. Permits for all seven stages of the development have now been granted. At completion, the development will accommodate 515 dwellings (id Consulting Pty Ltd 2017), including a mix of detached, semi-detached and attached housing types (Collie Pty Ltd 2012, 26)[63].

7.3.2 Findings

This section describes:

1. The WSUD practices included in the development
2. The SLUP tools that influenced the adoption of WSUD practices

[62] Under PEA s 8, the Minister is a planning authority, under the Act, who may prepare planning schemes, and amendments to any part of a planning scheme.

[63] As of 2016, all lots in the Coburg Hill development had been sold (Satterley Property Group Pty Ltd 2016). An inspection by the author in June 2017 found the civil works for the entire development were complete, all the detached dwellings were finished and a substantial number of semi-detached and attached dwellings were either complete, or under construction.

3. The influence of these tools on WSUD practices.

WSUD Practices Included in the Development

Coburg Hill includes a range of WSUD practices, which were identified by reviewing documents related to the development and the semi-structured interviews. These practices are:

1. Each dwelling is fitted with a rainwater collection and reuse system, which stores rainwater in a tank and uses it for toilet flushing, laundry and garden irrigation.
2. Raingardens[64] , which treat stormwater runoff from roadways, are installed in streets. The development includes some 45 of these street-scale raingardens. Figure 7-3 shows one of these installations.
3. A large biofiltration swale[65] is installed in the main entrance boulevard to the development, which treats stormwater runoff from the boulevard. The treated stormwater is discharged to the drainage system in Elizabeth Street. Figure 7-4 shows this biofiltration swale.
4. Two large end of line[66] raingardens, which treat stormwater, prior to its discharge to Edgars Creek.

This list demonstrates that Coburg Hill includes a diverse range of WSUD practices, at a range of physical scales.

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[64] A raingarden is a constructed garden that removes pollutants from stormwater and reduces stormwater peak flows. Raingardens can vary in size from small installations of a few square metres treating stormwater from individual dwellings, to much larger units of several hundred square metres, which treat stormwater runoff from an entire neighbourhood. See, for example, Christchurch City Council (2016).

[65] A biofiltration swale is a vegetated channel in the urban landscape, which treats stormwater flows that are directed into the channel. See, for example, California. Department of Transportation (2012).

[66] In this context, 'end of line' indicates that the raingardens provide the final treatment of stormwater runoff from that part of the development that drains to Edgars Creek, before the stormwater is discharged to the creek. The size of the larger raingarden is 500 square metres and the smaller is 150 square metres.

Figure 7-3: Raingarden Installed at the Coburg Hill Development

Source: Photograph by the author

Figure 7-4: Biofiltration Swale Installed in Entrance Boulevard, Coburg Hill

Source: Photograph by the author

Statutory Land Use Planning Tools that Influenced the Adoption of WSUD Practices

The document analysis and the semi-structured interviews identified a number of SLUP tools that influenced the adoption of WSUD practices at Coburg Hill. These tools will now be considered.

Moreland Planning Scheme, Clause 43.04 and Clause 56.07

The Moreland Planning Scheme is the statutory document that regulates land use and development in the City of Moreland. Clause 43.04 of the Scheme states that a permit for residential development of land subject to a development plan overlay must not be granted until a 'development plan' is prepared and approved by the responsible authority and, further, that this plan must comply with Clause 56 of the Scheme. Clause 56 includes an Integrated Water Management component, Clause 56.07[67], which requires the stormwater management system for a residential subdivision to meet the treatment targets in the *Urban stormwater best practice environmental management guidelines* (Victoria. Stormwater Committee 1999) (hereafter 'the BPEMG'). These are numeric targets, which require the stormwater system to remove at least 80 percent of suspended solids, 45 percent of nitrogen and 45 percent of phosphorus from the stormwater.

In summary, the overall effect of Clauses 43.04 and 56.07 is that, prior to the issue of a permit for residential development of land subject to a development plan overlay, a development plan must be prepared and approved, which demonstrates how specific stormwater treatment targets will be met.

Development Plan Overlay DPO 10 and Stormwater Drainage Master Plan

The Coburg Hill site was rezoned from industrial to residential use by Planning Scheme Amendment C111 to the Moreland Planning Scheme. This amendment placed a Development Plan Overlay (DPO 10) over the site, which included a Schedule of conditions[68]. These conditions specified what a development plan prepared under

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[67] In accordance with the Victoria Planning Provisions, Clause 56.07 is included in all planning schemes in Victoria.

[68] Planning Scheme Amendment C111 rezoned the greater part of the Coburg Hill site from industrial to residential land use. A small part of the site was rezoned from industrial to business use. Amendment C111 was prepared by the Minister for Planning, as the planning authority. Amendment C111 also made

Clause 43.04 of the Moreland Planning Scheme had to consider. A development plan was required to include a 'Stormwater Drainage Master Plan' that considered WSUD principles and the protection of Edgars Creek, and measures to retain, treat and/or reuse stormwater. The Schedule also required the development plan to include sustainability targets.

A Stormwater Drainage Master Plan was prepared in accordance with DPO 10, which described a stormwater system designed to comply with the treatment targets in the BPEMG. It also included targets to reduce potable water use and wastewater volumes. The development plan, including the Stormwater Drainage Master Plan, was approved by the Minister for Planning, as the responsible authority.

<u>Permits for stages of the development</u>

A permit had to be granted by Moreland City Council for each stage of the Coburg Hill project, before development of that stage could commence. Permits required the submission and approval of plans showing how the BPEMG stormwater treatment targets would be met, using the treatment regime described in the Stormwater Drainage Master Plan, before works commenced at that stage.

Overall then, the SLUP regime at Coburg Hill included a number of tools that required WSUD to be considered before development could proceed. The permits for stages of the development provided a compliance mechanism. Importantly, the regime mandated compliance with the stormwater treatment targets in the BPEMG.

The SLUP tools are also summarised in Table 7-1, following:

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the Minister for Planning the responsible authority, for the purposes of approving the development plan. Victoria, *Victoria Government Gazette,* No. G19, Thursday 7 May 2009, 1162.

Table 7-1: Statutory Land Use Planning Tools that Influenced WSUD Practices at Coburg Hill

Statutory Land Use Planning Tool	Requirements Related to WSUD Practices
Clause 43.04 of the Moreland Planning Scheme	This clause states (among other things) that a permit must not be granted for residential development of land subject to a development plan overlay, until a development plan has been prepared to the satisfaction of the responsible authority. The development plan must meet the requirements of Clause 56 of the Scheme.
Clause 56.07 of the Moreland Planning Scheme	This clause is titled **Integrated Water Management**. It requires (among other things) that urban stormwater management systems must meet the current best practice performance objectives for stormwater quality in the BPEMG.
BPEMG	This includes the following stormwater treatment requirements: • Removal of at least 80 percent of suspended solids • Removal of at least 45 percent of nitrogen • Removal of at least 45 percent of phosphorus.
Development Plan Overlay DPO 10 to the Moreland Planning Scheme and the Schedule to this Overlay	The Schedule to the Development Plan Overlay included requirements for proposed redevelopment of the Coburg Hill site. The Schedule required a development plan to include a Stormwater Drainage Master Plan, which considered: 1. WSUD principles and the protection of the environmental values of Edgars Creek, which adjoins the Coburg Hill site 2. measures to retain, treat and/or reuse stormwater, to improve stormwater quality and reduce the volume of stormwater discharged from the site. The Schedule also required the development plan to include sustainability targets for the site.
Coburg Hill Development Plan	A development plan was prepared in accordance with Development Plan Overlay DPO 10 and the associated Schedule and approved by the Minister for Planning on 12 July 2010. The Stormwater Drainage Master Plan component of the development plan set out a strategy to comply with the stormwater treatment requirements in the BPEMG. This strategy included the use of stormwater treatment assets at a range of physical scales, including rainwater tanks serving individual dwellings, street-scale raingardens, a bioretention swale in the entrance boulevard and end of line treatment ponds. The Master Plan also included targets to reduce potable water use and wastewater volumes.
Permits for stages of the development.	The permit for each stage required a report to be provided to Moreland City Council, demonstrating how the stormwater treatment targets in the BPEMG would be met, using the treatment regime in the Stormwater Drainage Master Plan. This report had to approved by Moreland before works on that stage could commence.

Source: original table

The influence of these statutory tools on WSUD practices will now be considered.

Influence of Statutory Land Use Planning on WSUD Practices

This section will firstly describe findings about the influence of SLUP on WSUD practices generally and, secondly, describe findings about the influence of statutory planning on the components of WSUD practice identified in this thesis.

During the semi-structured interviews, the interviewees were asked to rate the influence of SLUP on the implementation of WSUD practices generally, and on the implementation of the components of WSUD practice. The interviewees provided the responses summarised in Table 7-2:

Table 7-2: Responses to Rating-scale Questions about the Influence of Statutory Land Use Planning at Coburg Hill

Interviewee	Influence on the Adoption of WSUD Practices	Influence on the Urban Stormwater Management Component	Influence on the Urban Water Cycle Component	Influence on the Urban Water Infrastructure Component	Influence on the Urban Design Component
A	Encouraging	Encouraging	Neither encouraging or discouraging	Encouraging	Encouraging
B	Encouraging	Encouraging	Neither encouraging or discouraging	Neither encouraging or discouraging	Encouraging
C	Encouraging	Encouraging	Neither encouraging or discouraging	Neither encouraging or discouraging	Neither encouraging or discouraging
D	Strongly encouraging	Strongly encouraging	Encouraging	Strongly encouraging	Encouraging
E	Encouraging	Encouraging	Neither encouraging or discouraging	Neither encouraging or discouraging	Neither encouraging or discouraging
F	Strongly encouraging	Strongly encouraging	Encouraging	Neither encouraging or discouraging	Encouraging
G	Strongly encouraging	Strongly encouraging	Strongly encouraging	Encouraging	Neither encouraging or discouraging
H	Preferred not to answer question	Preferred not to answer question	Preferred not to answer question	Preferred not to answer question	Preferred not to answer question

General Findings About Influence of Statutory land Use Planning on WSUD Practices

According to the interviewees, SLUP did favourably influence the implementation of WSUD at Coburg Hill. When asked to rate the influence of SLUP on the adoption of WSUD practices, the responses were as shown in Table 7-3:

Table 7-3: Responses to Question about the Influence of Statutory Land Use Planning on the Adoption of WSUD Practices at the Coburg Hill Development

Response	Number of responses
Strongly encouraging	3
Encouraging	4
Neither encouraging or discouraging	0
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	1

To put the influence of SLUP in context, the interviewees were also asked about the range of factors that influenced the adoption of WSUD practices, and the importance of SLUP in that range of influences. There was strong agreement that these practices would not have been implemented, in the absence of SLUP requirements. This point was clearly expressed by the comment that 'Statutory planning was the number one driver. Whilst it may have occurred without it, more than likely it wouldn't have. So statutory planning…is what drives water sensitive urban design in our municipality' (interviewee F). The same interviewee observed that 'The good juxtaposition to look at, that is Pentridge development within our municipality before Clause 56.07 came in. Zero water sensitive urban design. The juxtaposition to that is Coburg Hill. After Clause 56.07 came in, Coburg Hill meets best practice and it's actually a fairly robust design'. The mandatory nature of SLUP was identified as the reason for its ability to ensure that WSUD practices were incorporated in the development. SLUP 'gives you that regulatory framework that in the end they have to comply with to get a tick' (interviewee E) or, as interviewee B put it, the mandatory nature of SLUP makes it 'quite clear what we are supposed to do'.

The statutory requirements related to WSUD were set out in an integrated, comprehensive set of SLUP tools. As noted in Table 7.1, these included:

1. Clause 43.04 of the Moreland Planning Scheme, which directs that a planning permit not be granted for a site subject to a Development Plan Overlay, until a development plan has been prepared that complies with Clause 56 of the Scheme
2. Clause 56.07 of the Moreland Planning Scheme, which references the BPEMG
3. Development Plan Overlay DPO 10 and its associated Schedule
4. The development plan prepared in accordance with DPO 10, which included a Stormwater Drainage Master Plan.

Together, these established a consistent, mandatory set of requirements related to WSUD[69]. The Stormwater Drainage Master Plan component of the development plan

[69] The interviewees tended to focus on different statutory tools, reflecting their differing roles in the Coburg Hill development. Taken together, the interviews and the document analysis identified the consistent, mandatory set of requirements listed in points (1) to (4) as critical to the adoption of WSUD practices.

identified the types of WSUD measures to include in the development, to comply with the BPEMG. Following the approval of the development plan by the Minister for Planning, 'the development plan is the point of reference for planning, as well as the Planning Scheme, the two documents really sit side by side and guide what happens on the site' (interviewee D). The planning permits for individual stages of the development required that WSUD measures be installed in accordance with the Stormwater Drainage Master Plan, so that 'each and every subdivision permit application…demonstrated to council…how as an overall development how we were tracking in terms of meeting the end objectives, to make sure that even at the first stage of subdivision we were not losing track of the end game' (interviewee D). Overall then, the statutory planning tools provided a comprehensive regime, which was established early in the development process and ensured that the required WSUD measures were included in the development.

A key element of the statutory planning regime was the presence of explicit targets. The BPEMG defined specific stormwater treatment targets for removing suspended solids, nitrogen and phosphorus. The Stormwater Drainage Master Plan adopted these targets and also specified targets for reducing potable water consumption and wastewater volumes[70]. A strong, consistent theme in the interviews was the certainty and clarity that targets provided. This was clearly expressed by the statement by interviewee C that 'essentially the statutory planning controls were you must meet X, Y and Z percentage reduction of nitrogen, phosphorus and TSS[71]. So that was the driver to start

[70] The Stormwater Drainage Master Plan included targets to reduce both water consumption and wastewater volume by 40 percent. The Master Plan indicated that these reductions would be met via the Water Efficiency Labelling Scheme (WELS). WELS, introduced in 2005, under the *Water Efficiency Labelling and Standards Act 2005* (Cth) and complementary legislation in states and territories, provides for household appliances using water to be given 'star' ratings, to encourage the adoption of water efficient products. A mandatory minimum water efficiency standard was introduced for toilets. The WELS legislation is not statutory land use planning. The water and wastewater targets in the Master Plan therefore reflected reductions that would have been achieved in any case via WELS, without statutory land use planning intervention.

The Master Plan also stated that rainwater tanks should be used to provide a margin of safety, beyond WELS, ensuring that the targets to reduce potable water use and wastewater volumes would be met comfortably. The role of rainwater tanks in reducing water consumption, and stormwater volumes, is discussed later in this section.

[71] Total suspended solids.

the process of WSUD'. Interviewee F spoke about the clarity associated with explicit targets, and the uncertainty that can occur if targets are absent:

> So having clear targets and the ability to assess them, against them, makes it easier to determine if a development is going to comply or not…having those targets makes it very set on what they need to do to get there. And clarity is really helpful in making those decisions. When there isn't clarity, then you often end up with a poor outcome because it can be interpreted in many different ways.

The developer was an active participant in the design of the SLUP framework, ensuring that the developer was aware, at a very early stage, of the scope of the WSUD requirements. According to a planning consultant to the developer, 'when I first got involved, there was no overlay in place and the land was zoned industrial…So our first involvement was even before that and initially we were talking to council about what the framework ought to be' (interviewee D). The role of WSUD was considered during these discussions about the SLUP regime for Coburg Hill, including the development plan. As interviewee D explained, 'within the development plan, water sensitive urban design, water quality, was a requirement, something we had to deliver on, and it, the development plan, called up the need for a Stormwater Drainage Master Plan'. At Coburg Hill, the developer was aware of the WSUD requirements from the very start of the statutory planning process. An engineering consultant indicated that being aware of the WSUD requirements early in the planning process helped to integrate stormwater management measures with the development. Interviewee B explained that:

> One of the best things that the statutory planning things can do is be sure when you get planning conditions for that site, you need to have a stormwater management strategy prepared and that is approved with the urban development layout there…in this case…we were in early looking at the urban drainage and the stormwater management side of it.

The early engagement of the developer with the SLUP process helped to ensure that WSUD was considered throughout the entire development cycle.

The flexibility of the SLUP system was another reason why SLUP encouraged the adoption of WSUD practices. The interviews spoke of two types of flexibility. Firstly, while quantitative urban water management targets were set, the developer had the capacity to design appropriate technical solutions to meet these targets, without being bound by prescriptive rules about treatment technology[72]. Secondly, the statutory

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[72] In Victoria, the ability of proposed treatment systems to meet the stormwater treatment targets in the BPEMG may be assessed by computer modelling, using programs such as MUSIC (eWater 2015). The

planning system allowed WSUD practices to be adopted that recognised the varying constraints associated with each stage, while ensuring that the overall development would comply with the BPEMG targets. These two types of flexibility will now be considered in more detail.

The specific technical measures used to comply with the BPEMG were determined by the developer. Thus, innovative solutions, appropriate for a specific site, could be implemented: 'nothing is set in stone, so it does allow innovation…if you are in a particular circumstance, where you want to either create a point of difference, or just for financial reasons, do something a little bit different, you have the flexibility to explore other techniques' (interviewee C). This meant that 'the opportunity was there to make sure that water sensitive urban design was tailored and specific for this site' (interviewee D). These comments indicate that the statutory system allowed appropriate, site-specific measures to be installed.

The SLUP system permitted targets to be applied to the development as a whole, rather than to individual stages. Coburg Hill was a staged development, where physical factors that can affect the design of urban stormwater systems, such as slopes, street layouts and dwelling types, varied between stages. However, the targets applied to the development as a whole, rather than to individual stages. This process was described by interviewee F: 'we had here a...whole of site plan, and it broke down and said in each stage they would undertake these specific measures. And at the end it would come together to meet best practice. So not each stage itself met best practice as a stand-alone stage, but the site as a whole meets best practice'. This flexibility allowed WSUD measures to be installed that reflected the physical constraints affecting each stage, while ensuring that the entire development would meet the targets.

Victorian government has indicated that the results of such modelling can be used, in planning applications for residential subdivision, as evidence that the BPEMG targets will be met (Victoria. Department of Sustainability and Environment 2006). Modelling results are assessed by the local government that receives the permit application, typically in consultation with Melbourne Water (in Melbourne Water's area of responsibility).

The preceding discussion considered the influence of SLUP on the adoption of WSUD practices generally, without considering the specific components of WSUD practice. The following discussion examines the influence of SLUP on each of these components.

Findings About the Components of WSUD Practice

Urban Stormwater Management

Table 7-4 shows how the interviewees rated the influence of SLUP on the urban stormwater management component of WSUD practice at Coburg Hill:

Table 7-4: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Stormwater Management Component of WSUD Practice at Coburg Hill

Response	Number of responses
Strongly encouraging	3
Encouraging	4
Neither encouraging or discouraging	0
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	1

The discussion in the semi-structured interviews was consistent with these ratings. The comments from all the interviewees stated that SLUP encouraged the adoption of urban stormwater management practices.

This encouragement was attributed to the explicit, mandatory stormwater management targets specified by SLUP tools, particularly Clause 56.07 of the Moreland Planning Scheme, which references the stormwater treatment requirements in the BPEMG. This was expressed by comments such as ‘ the influence comes from Clause 56. It mainly impacts on the quality and quantity of stormwater runoff’ from interviewee F, and ‘Clause 56 was probably the main driver for the application of water sensitive urban design in this development’ from interviewee A. A technical consultant emphasised the mandatory nature of the stormwater management requirements: ‘it provided the regulatory framework that forced them to do it. You’ve got Clause 56…from the stormwater side of things…it usually gives me the ammunition to say you have to do this, there is no option’ (interviewee E).

Neither the document review nor the interviews identified any aspects of the SLUP system that inhibited its ability to influence the urban stormwater management component.

Urban Water Cycle

The interviewees rated the influence of SLUP on the urban water cycle component of WSUD practice at Coburg Hill as far more modest. Table 7-5 summarises their ratings:

Table 7-5: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Water Cycle Component of WSUD Practice at the Coburg Hill Development

Response	Number of responses
Strongly encouraging	1
Encouraging	2
Neither encouraging or discouraging	4
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	1

Participants who provided *Neither encouraging or discouraging* responses suggested that, in their view, SLUP lacked clear requirements relating to the broader urban water cycle, in contrast to the explicit targets for urban stormwater. As interviewee B noted, ‘It's not clear in terms of the use of, it doesn’t talk about mandating the use of recycled water or anything like that, or just putting recycled water in, how you can get outcomes in an integrated manner, it's very much in the line of just stormwater management and that's it’. A similar comment was made by interviewee F when they said that SLUP ‘isn’t active on the broader water cycle as such. It only has specific targets and specific areas in which it works in, and the larger water cycle is not one of those. It looks at the stormwater management runoff’. Those participants who provided *Encouraging/Strongly encouraging* responses considered that SLUP identifies the urban water cycle as an issue to be considered, without identifying specific outcomes. Interviewee D typified this view when they said ‘I see the statutory system as putting the framework in place to ensure this isn't overlooked, and I think it probably achieved what it had to achieve from that point of view. I don't think it in itself, the statutory process either helps or hinders, is it simply ensures that it is considered’.

Particularly useful insights were provided by the consultant who prepared the Stormwater Drainage Master Plan component of the development plan. The Master Plan indicated that rainwater tanks should be used to capture runoff from roofs and reuse this water for toilet flushing, laundry use and garden irrigation. This reuse reduces Coburg Hill's demand for potable water, which provides benefits for the urban water cycle as a whole. However, the main reason for the adoption of rainwater tanks was to reduce the volume of stormwater that had to be treated[73]. As interviewee E said, when discussing stormwater, 'there was a big push to look at how much reuse of stormwater, roof water could be made of at the site…the driver for that was the more you could reuse, the less you had to treat. When you are space confined, if you don't have to treat it, that is a far better outcome'. While the SLUP system mandated the installation of rainwater tanks, providing some benefits for the broader urban water cycle, the dominant factor in using rainwater tanks was their contribution to reducing the stormwater treatment task.

Urban Water Infrastructure

Interestingly, the interviewees again rated the influence of SLUP on the urban water infrastructure component of WSUD practice at Coburg Hill as modest. Table 7.6 summarises these ratings:

Table 7-6: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Water Infrastructure Component of WSUD Practice at the Coburg Hill Development

Response	Number of responses
Strongly encouraging	1
Encouraging	2
Neither encouraging or discouraging	4
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	1

[73] In the absence of rainwater tanks, runoff from roofs enters the stormwater drainage system and adds to the volume of stormwater to be treated. Rainwater tanks collect runoff from roofs and use it for purposes such as toilet flushing, laundry use and garden irrigation. Water used for toilet flushing and laundering is ultimately directed to the sewerage system, instead of the stormwater system. Water used for garden irrigation is mostly lost to the atmosphere by the process of evapotranspiration. Thus, rainwater tanks divert runoff from roofs away from the stormwater system and reduce the volume of stormwater that requires treatment.

The participants who provided *Neither encouraging or discouraging* responses indicated that, in their view, SLUP does not include explicit requirements that relate to the provision of urban water infrastructure. According to a technical consultant, 'there is a requirement that you meet Clause 56[74], but how you get to that point is limiting and there is no guidance or there is no encouragement' (interviewee B). The participants who provided *Encouraging/Strongly encouraging* responses suggested that the SLUP regime for Coburg Hill, as a whole, had brought about the installation of urban water infrastructure, at a range of physical scales. As interviewee D said, 'I would probably say strongly encouraging. I think again all those documents led us to the suite of systems that we ultimately had in there'.

Particularly useful insights into the motivation for the installation of urban water infrastructure, at a range of scales, were provided by the engineering consultant who prepared the Stormwater Drainage Master Plan and the developer's project manager. They both indicated that this approach provided a cost-effective way to treat stormwater at this site. The consultant (interviewee E), for instance stated that 'the emphasis was on reuse, try and reuse as much as you could, so that you didn't have to treat as much back in the street or the public environment. They just didn't have the space to go on building wetlands or stuff like that' and 'you didn't have to do stuff in the streets, you didn't have to use raintanks, you didn't have to do this or do that, but you did have to meet the performance target[75]'. Turning to the street-scale raingardens, the project manager indicated that they were installed to reduce the land take required for large-scale end of line treatment, making more lots available for sale[76]. The following comments from interviewee C provide very useful insights:

> It was less of a statutory planning requirement than a desire for us as a developer to save money…we knew we had an obligation to treat water, it was just a matter of how we treated the water. The traditional method would be just build a big wetland and let that treat the water, and from a construction cost that would have been a cheaper option, but from a land budget it definitely was not a cheap option. So you…have construction cost as one criterion, what is the cost of land is the other criterion…It really made sense for us to reduce the size of the infrastructure, so we could sell more lots.

[74] This is a reference to meeting the stormwater treatment requirements in the BPEMG referenced by Clause 56.07.

[75] That is, the stormwater treatment targets in the BPEMG.

[76] The street-scale raingardens were installed in road reserves, so land did not have to be set aside for them. Overall, the use of street-scale raingardens, combined with a smaller end of line treatment system, resulted in less land being set aside for stormwater treatment.

> Basically it was, when we first got the project, I looked at the construction costs and said we have a problem, we need to minimise construction costs…We in fact did the reverse, we increased our construction cost but massively increased our revenue[77], by having another 15 lots at 500 grand each, sort of thing.

The comments by the engineering consultant and the project manager provide strong evidence that the installation of decentralised urban water infrastructure at Coburg Hill, including rainwater tanks and street-scale raingardens, was a cost-effective approach to treating urban stormwater to comply with the BPEMG. This interpretation is consistent with the statement by a Moreland City Council engineer (interviewee F) that:

> the whole stormwater approach, is a mixture of centralised and decentralised…you've got rainwater tanks in houses, you've got raingardens on the street, however, probably about 50% of the treatment comes from a centralised large-scale. So it's a bit of both. In terms of the statutory planning pushing that, that had no effect on that at all. It was just through meeting the stormwater quality targets.

Urban Design

Table 7-7 shows the influence of SLUP on the urban design component of WSUD practice at Coburg Hill, according to the interviewees:

Table 7-7: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Design Component of WSUD Practice at the Coburg Hill Development

Response	Number of responses
Strongly encouraging	0
Encouraging	4
Neither encouraging or discouraging	3
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	1

The interviews suggested that the perspectives, or interpretations of urban design outcomes, associated with the *encouraging* responses were different from those associated with the *neither encouraging or discouraging* responses. The *encouraging* ratings were generally associated with discussions about how specific WSUD practices were incorporated in the development, which did not extend to the overall design of Coburg Hill. These discussions included references to accomodating rainwater tanks on housing lots, the design of the street-scale raingardens and the design of the large end

[77] Street-scale raingardens are more expensive to construct than end of line systems providing the same treatment capacity. However, the reduced land set aside for stormwater treatment, due to the use of street-scale raingardens, allowed additional lots to be sold. The revenue from the sale of these lots exceeded the increased construction costs.

of line raingardens. According to interviewee F, the planning permit process allowed factors associated with the street-scale raingardens, including their locations, the vegetation selection and the provision of buffers to be influenced by the Moreland City Council. Interviewee D emphasised the integration of WSUD measures with the surrounding environment, so that in permit applications:

> we needed always to demonstrate to council that these things we were doing were part of a considered picture, that they weren't just a tack on…when we were building relatively small houses on small lots, we had to demonstrate that we had allowed sufficient space to put a water tank there. It wasn't enough to show a house, a garage and an outdoor space, and leave the water tank for the owner to resolve that issue. And…where we needed to have our wetland system…we wanted that also to be an attractive feature, so that it was not just an engineering function, but also a landscape function and also an educational function

A different, broader perspective was associated with the *neither encouraging or discouraging* responses. These ratings were supported by comments about the overall design of Coburg Hill. Particularly useful comments were provided by a Moreland City Council urban planner, who had a detailed understanding of the planning context for the development. They discussed the range of factors that determined the overall design of Coburg Hill and indicated that WSUD (interviewee G):

> was one of the things that went into the mix, but it probably wasn't the overarching or driving component. So things that really drove the composition and layout of the estate and the lots were the fact that Council wanted a linear park that provided recreational public space to get from Elizabeth Street to the creek…it is further influenced by where the roads go…and then the overarching driver in the Planning Scheme is orientation for daylight access…so WSUD wasn't the driver of the urban design outcomes. That was very much driven by other development requirements and I guess the thing about WSUD is that you can integrate it into, because you can deliver it in a number of different ways, you can integrate it into different designs

These comments indicate that WSUD was secondary to other considerations in determining urban design outcomes at Coburg Hill. Clearly, other considerations influenced the design of Coburg Hill and urban water cycle management was accommodated within the resulting urban form.

7.3.3 Conclusions from the Coburg Hill Case

An integrated set of SLUP tools influenced WSUD practices at Coburg Hill. These tools included explicit references to WSUD. The SLUP system identified the need to consider WSUD before the development commenced and continued to provide oversight as the development took place, via the permit process. Thus, SLUP ensured that WSUD was considered throughout the development cycle.

The developer participated in the preparation of the statutory planning regime. The developer was therefore aware of WSUD requirements at the earliest possible period and was able to consider how to integrate WSUD practices with the development.

The SLUP regime included explicit requirements related to urban stormwater treatment. These targets provided certainty for the developer and consultants, and strongly influenced the implementation of WSUD practices.

While the statutory system did include explicit urban stormwater management targets, it allowed the developer to design appropriate, site-specific technical solutions to meet these targets. The statutory planning system also provided the flexibility to recognise the varying constraints associated with each stage of the development, and set appropriate targets for each stage, while ensuring that the overall development would comply with the stormwater management requirements.

The SLUP system did recognise the urban water cycle component of WSUD practice, in that it included potable water reduction and wastewater reduction targets. However, these targets reflected reductions that would have occurred via the Water Efficiency and Labelling Scheme, without statutory planning intervention. Rainwater tanks were also identified as a method to meet the targets, but they were primarily intended to reduce stormwater runoff, and the associated treatment task, at a confined development site. Overall, the recognition of the urban water cycle component of WSUD practice in the SLUP system was confined to targets that did little to change conventional practice and the system’s influence on this component was limited.

Urban water infrastructure at a range of physical scales was installed at Coburg Hill. This took place in the absence of explicit objectives about the use of decentralised infrastructure, and corresponding objectives and targets. Instead, the use of a combination of infrastructure, at different scales, was a cost-effective way to comply with the stormwater treatment requirements.

There were positive urban design outcomes associated with urban water infrastructure. However, these were restricted to ensuring that the design of individual elements, such as rainwater tanks and street-scale raingardens, was sympathetic to the adjacent urban environment. The overall form of the development was determined by a range of planning factors, of which urban water cycle management was a subsidiary consideration.

Table 7-8, below, summarises factors that enhanced, or inhibited the ability of SLUP to influence WSUD practices at Coburg Hill:

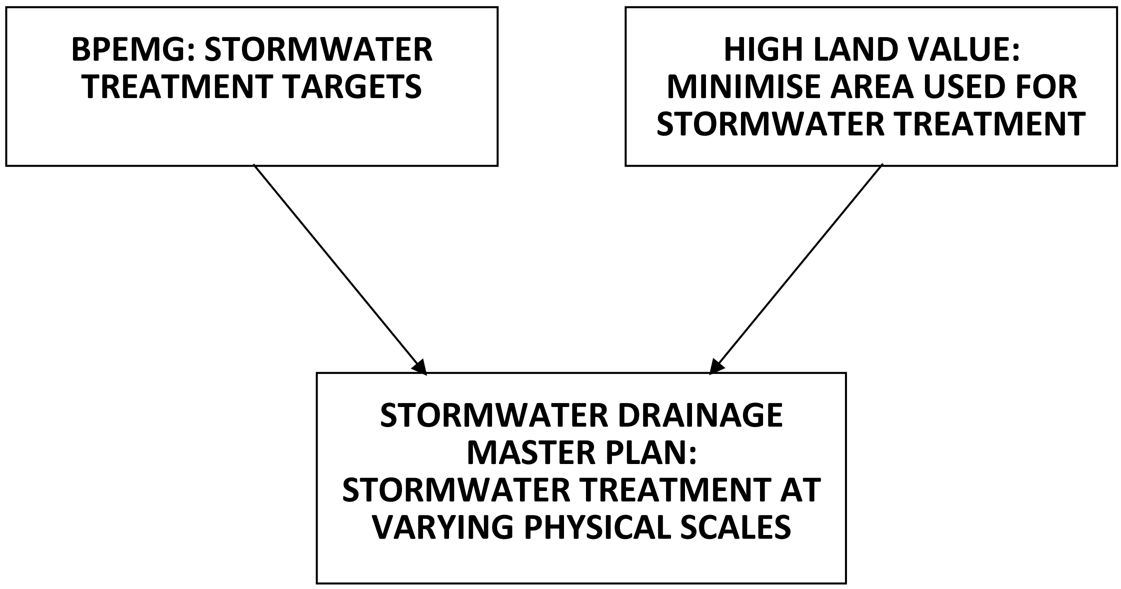
Table 7-8: Factors that Enhanced or Inhibited the Ability of Statutory Land Use Planning to Influence WSUD Practices at Coburg Hill

Enhancing Factors	Inhibiting Factors
• Comprehensive, integrated set of statutory land use planning tools that addressed WSUD • Early, thorough engagement with the developer in the preparation of the statutory land use planning regime • Clear, explicit targets for urban stormwater treatment • Flexibility to develop appropriate technical solutions to comply with the stormwater treatment targets • Flexibility to recognise the constraints associated with individual stages, while ensuring that the overall development would comply with the stormwater treatment targets • Permit process ensured that WSUD requirements were implemented at each stage of the development.	• Urban water cycle targets to reduce potable water consumption and wastewater volume had little influence on practices • Lack of recognition, and requirements, related to the urban water infrastructure component of WSUD practice • WSUD was, in reality, subsidiary to other land use planning considerations in the overall design of the development.

Source: original table

This table provides an understanding of individual, proximate factors related to the influence of SLUP on WSUD practices. However, a broader understanding is achieved by examining the <u>process</u> whereby SLUP influenced WSUD practices. This took place by influencing the design of the stormwater management infrastructure, in the context of a development site with high land values. Schematically we might represent this as shown in Figure 7-5 below:

Figure 7-5: Process by Which Statutory Land Use Planning Influenced WSUD Outcomes at Coburg Hill



Source: original figure

Figure 7-5 shows that a combination of the BPEMG's stormwater treatment requirements and the high land value at Coburg Hill lead to the adoption of a stormwater system that included a combination of centralised and decentralised measures. This strategy met the BPEMG targets, while minimising the amount of developable land set aside to accommodate stormwater treatment infrastructure.

SLUP strongly influenced the urban stormwater management component of WSUD practice. While there were some positive outcomes related to the urban water cycle, urban water infrastructure and urban design components of WSUD practice, these were essentially by-products of complying with the stormwater management requirements set out in the SLUP regime.

7.4 Case Study: Davis Road East, Tarneit, Melbourne

This section describes the second Victorian case study. This case examines how SLUP influenced the adoption of WSUD practices at a residential development at Davis Road East, Tarneit, Melbourne. The range of WSUD practices at Davis Road East is less comprehensive, compared with Coburg Hill.

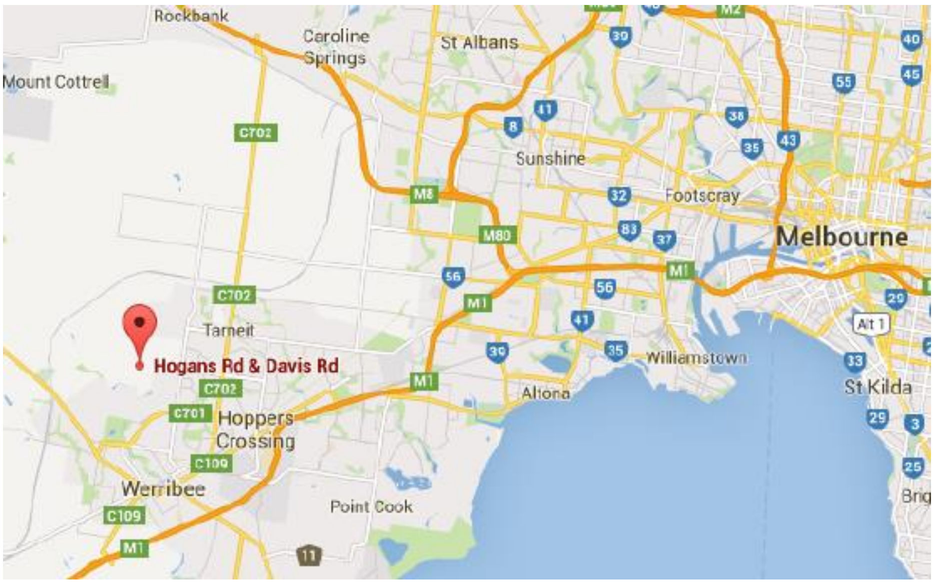
Section 7.4.1, following, describes the development. Section 7.4.2 then reports the findings of the case study, and section 7.4.3 draws conclusions from the findings.

7.4.1 Description of the Davis Road East Development

Physical Setting

This is a 75 hectare greenfield residential development, located on former grazing land. Davis Road East was the first part of a 234 hectare site, known as the Grove, to be developed (interviewee N). Davis Road East is situated some 31 kilometres west of Melbourne's Central Business District, within the local government area administered by the Wyndham City Council. The site's location is identified as 'Hogans Rd & Davis Rd' in Figure 7.6:

Figure 7-6: Location of the Davis Road East Development



Source: map data ©2016 Google

When completed, the subdivision will include some 1,000 dwellings (interviewee N). The site is bounded by roads to the west and south, while Davis Creek forms an eastern boundary, as shown in Figure 7.7:

Figure 7-7: The Davis Road East Development, Tarneit, Melbourne

Source: Planning Panels Victoria, 6

The subdivision is located in Melbourne's West Growth Corridor, which will accommodate a population projected to increase from 370,000 in 2013 to 430,000 in 2031 (Victoria. Department of Transport, Planning and Local Infrastructure 2014, 29). Davis Road East represents a typical greenfield residential development in a Melbourne growth corridor.

Change of Land Use to Residential

Given the number of steps needed to change the land use at Davis Road East from non-residential to residential, it is useful to summarise them, as shown in Table 7-9:

Table 7-9: Key Steps in the Change of Land Use at Davis Road East to Residential

Date	Step
December 2008	Review of Melbourne's Urban Growth Boundary announced
August 2010	The Urban Growth Boundary was extended, bringing Davis Road East within the Boundary. The boundary was extended via Planning Scheme Amendment VC68[78], which also rezoned a substantial area of land in the City of Wyndham from Rural Conservation Zone to Urban Growth Zone.
June 2012	West Corridor Growth Plan published, indicating that the Davis Road East site was suitable for urban development
September 2012	Application lodged for a permit to subdivide land at Davis Road East
June 2013	Initial Riverdale Precinct Structure Plan (PSP) published, which included the Davis Road East site.
April 2014	Planning Panels Victoria recommended that the Wyndham Planning Scheme be amended to adopt the Riverdale PSP, and the permit to subdivide the land at Davis Road East be granted
September 2014	Final Riverdale PSP published.
November 2014	The Minister for Planning amended the Wyndham Planning Scheme to adopt the Riverdale PSP and determined that a permit for the Davis Road East subdivision should be granted.

Source: original table

[78] Victoria, *Victoria Government Gazette,* No. S310, Friday 6 August 2010.

The changing land use at Davis Road East reflects continued population growth in Melbourne. Melbourne's low density urban form is like that of other Australian cities, which have 'sprawled further and faster than any other cities in the world' (Newman 1992, 485). In 2002, the Victorian government introduced an Urban Growth Boundary, intended to control Melbourne's apparently inexorable outward growth (Victoria. Department of Infrastructure 2002). The Davis Road East site was outside this boundary. However, the Urban Growth Boundary had to be reviewed, largely because of an increased population trajectory (Victoria. Department of Planning and Development 2008). The Boundary was extended in 2010, bringing Davis Road East within the Boundary and changing the zoning of a substantial area in the City of Wyndham from Rural Conservation Zone to Urban Growth Zone. The Urban Growth Zone 'applies to land that has been identified for future urban development within the Urban Growth Boundary…It has been specifically designed to implement an incorporated PSP and ensure that future development accords with the approved PSP' (Planning Panels Victoria, 22). A Victorian Government report, released in 2012, identified the Davis Road East area as potentially suitable for urban development (Victoria. Growth Areas Authority, 38).

Victorian government policy at this time was to direct Melbourne's outward growth into corridors, including a West Growth Corridor (Victoria. Growth Areas Authority 2012). The Victorian government's Growth Areas Authority[79] prepared a precinct structure plan (PSP), to facilitate residential development of some 1,100 hectares in the West Growth Corridor, including the Davis Road East site. PSPs are master plans for future urban developments, with populations typically ranging from 10,000 to 30,000 (Corbett 2012, 2957). PSPs are not statutory tools, but are prepared with the intent of including their provisions in planning schemes, to give them statutory force. An initial version of the PSP was published in June 2013 as the Riverdale Precinct Structure Plan ('Riverdale PSP')

[79] The Growth Areas Authority (GAA) was a statutory authority established by the *Planning and Environment (Growth Areas Authority) Act 2006* (Vic), which amended the PEA. The 2006 Act charged the GAA with coordinating development in Melbourne's growth areas. The Act provided for the powers and functions of a planning authority and a responsible authority to be delegated to the GAA in growth areas. The GAA was referred to as the Metropolitan Planning Authority from October 2013 to August 2016, although its legislative basis was largely unchanged (Metropolitan Planning Authority 2015). The term Metropolitan Planning Authority was replaced by Victorian Planning Authority in August 2016. These changes in nomenclature reflect changes in state government policies and priorities, rather than statutory changes.

(Victoria. Growth Areas Authority 2013). A final version of the Riverdale PSP was published in September 2014 (Victoria. Metropolitan Planning Authority 2014).

While the Riverdale PSP was in preparation, an application for a permit to subdivide the Davis Road East site was submitted to the Growth Areas Authority[80]. The applicant requested that the permit application be considered concurrently with the proposed inclusion of the provisions of the Riverdale PSP in the Wyndham Planning Scheme.

In accordance with the PEA, a panel was convened to consider the incorporation of the Riverdale PSP in the Wyndham Planning Scheme and the application to subdivide the Davis Road East site (along with a number of other related amendments and permit applications)[81]. In April 2014, the panel recommended that the Wyndham Planning Scheme should adopt the Riverdale PSP, subject to some amendments, and that a permit should be granted (Planning Panels Victoria 2014). On 13 November 2014, the Minister for Planning approved amendment of the Wyndham Planning Scheme to incorporate the Riverdale PSP, and also determined that a planning permit should be granted[82]. Upon the issue of the permit, the Wyndham City Council became the responsible authority, charged with the administration and enforcement of the permit.

7.4.2 Findings

This section will describe:

1. The WSUD practices included in the development
2. The SLUP tools that influenced the adoption of WSUD practices
3. The influence of these tools on WSUD practices.

[80] The PEA pt 4 div 5 provides for a combined planning scheme amendment and planning permit process. Under this process, the planning authority (the Growth Areas Authority in this instance) assesses both the proposed amendment and the permit application.

[81] Under s 24 and s 25 of the PEA, a panel may be convened to consider proposed planning scheme amendments and to make recommendations to the planning authority. Under s 96E of the PEA, when a combined planning scheme amendment and planning permit process takes place, the panel may also consider, and makes recommendations about, the permit.

[82] Victoria, *Victoria Government Gazette,* No. G 46, Thursday 13 November 2014, 2668.

WSUD Practices Included in the Development

The document review and the semi-structured interviews found that the development will include the following WSUD practices[83]:

1. Collection of stormwater runoff from the development, from storms up to the 1 in 5 year average recurrence interval event[84], by a piped underground drainage system, and treatment of the stormwater to meet the targets in the BPEMG[85]. The site includes four sub-catchments. Each of the three largest sub-catchments will use a wetland[86], to treat the stormwater from that sub-catchment (resulting in a total of three wetlands, one for each of the three sub-catchments). The stormwater from the fourth, smallest, sub-catchment will be directed to a sedimentation pond, to remove large particles from the stormwater, and will then be then piped to one of the treatment wetlands. The wetlands and the sedimentation pond will be installed in the Davis Creek Corridor, which cannot be subdivided for residential purposes. Figure 7-8 shows a stormwater treatment wetland under construction.
2. Buildings must incorporate dual plumbing, able to use recycled water for toilet flushing and garden watering[87], and the developer must accept recycled water from the water service provider. A marker denoting the presence of the recycled water supply system is shown in Figure 7-9.

The development does not include street-scale, decentralised urban water infrastructure.

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[83] An inspection of the site by the author in June 2017 indicated that most lots in the Davis Road East development had been sold and that construction of around 150 dwellings had been completed, or was underway. Construction of the first stormwater treatment wetland was taking place and a recycled water system had been installed.

[84] The average recurrence interval, ARI, refers to the average value of the periods between exceedances of a given event (Institution of Engineers Australia Pilgrim D. H. (Ed) 1987, 7).

[85] Flows from large storms exceeding the one in five year event, up to the one in 100 year event, are conveyed via road reserves to the Davis Creek waterway corridor. Large stormflows from Davis Road East are managed by Melbourne Water's regional drainage system, according to interviewee M.

[86] A stormwater treatment wetland is an engineered wetland that uses natural biological processes to remove pollutants, such as solids and plant nutrients. They are a very common treatment method. See, for example, Kadlec and Wallace (2008).

[87] 'Recycled water' refers to water recovered from sewerage systems, treated so it can be used for its intended purposes. See, for example, Victoria. Environment Protection Authority (2005).

Figure 7-8: Construction of Stormwater Treatment Wetland, Davis Road East

Source: Photograph by the author

Figure 7-9: Marker Showing Recycled Water Supply, Davis Road East

Source: Photograph by the author

Statutory Land Use Planning Tools that Influenced the Adoption of WSUD Practices

The document analysis and the semi-structured interviews identified a number of SLUP tools that influenced the adoption of WSUD practices at Davis Road East. These tools, and the requirements related to WSUD in each tool, will now be considered.

Clause 56 of the Wyndham Planning Scheme and the BPEMG

The Wyndham Planning Scheme is the statutory document that regulates land use and development in the City of Wyndham. The Scheme includes Clause 56.07 which, as noted in the Coburg Hill case study, requires the stormwater management system for a residential subdivision to meet the treatment targets in the BPEMG.

Riverdale Precinct Structure Plan[88]

This Plan included nineteen high-level policy objectives. One objective was to adopt a water management system that 'encourages reduced reliance on reticulated potable water…the re-use of alternative water, minimises flood risk, ensures waterway health and contributes towards a sustainable and green urban environment'. The Plan also included a map identifying the location of sub-catchment scale stormwater treatment systems at the Davis Road East site and an Integrated Water Management section. The Integrated Water Management section required stormwater runoff to meet or better the treatment targets in the BPEMG. It also provided guidance which indicated that, at the street-scale, development should be designed to facilitate the adoption of WSUD initiatives, to contribute to a sustainable, green urban environment.

The Riverdale Precinct Structure Plan was formally included in the Wyndham Planning Scheme via Planning Scheme Amendment C176[89].

[88] As noted previously, the Precinct Structure Plan is not, of itself, a statutory tool, but it did acquire statutory force, when it was incorporated in the Wyndham Planning Scheme. Given its later statutory recognition, it is appropriate to include the Precinct Structure Plan in this discussion of the statutory tools at Davis Road East. An initial version of the Precinct Structure Plan was published in June 2013 and a final version was published in September 2014. The urban water management obligations in the two versions were identical.

[89] Victoria, *Victoria Government Gazette,* No. G46, Thursday 13 November 2014, 2668.

Planning Permit WYP 6217/12 and Stormwater Management Strategy

This permit allowed subdivision of the Davis Road East site into housing lots. The permit stated that before subdivision could proceed, a Stormwater Management Strategy must be prepared to the satisfaction of Wyndham City Council and Melbourne Water, which considered a range of WSUD initiatives. Importantly, the initiatives included increased use of WSUD in the development and localised, street-scale harvesting of stormwater, to enhance urban amenity. The permit also required the development to have the capacity to utilise recycled water.

A Stormwater Management Strategy was prepared in accordance with the permit. It described a system to collect stormwater via a piped underground drainage network and treat the stormwater to meet the BPEMG targets, using four sub-catchment scale treatment units. The Strategy did not include decentralised, street-scale WSUD practices[90].

Thus, the SLUP regime at Davis Road East included a number of tools that referred to WSUD. The need to treat stormwater to meet the targets in the BPEMG was clearly identified. The use of decentralised, street-scale WSUD practices also had to be considered.

The SLUP tools are also summarised in Table 7-10 below:

[90] The planning permit had the effect of incorporating a plan of subdivision, including the stormwater treatment regime shown in the Stormwater Treatment Strategy, in the permit. The permit is a statutory tool made under the PEA. Thus, the Stormwater Treatment Strategy had statutory force.

Table 7-10: Statutory Land Use Planning Tools that Influenced WSUD Practices at Davis Road East

Statutory Land Use Planning Tool	Requirements Related to WSUD Practices
Clause 56.07 of the Wyndham Planning Scheme	This clause is titled **Integrated Water Management**. It requires (among other things) the stormwater management system for a residential subdivision to meet the treatment targets in the BPEMG.
BPEMG	This includes the following stormwater treatment requirements: 1. Removal of at least 80 percent of suspended solids 2. Removal of at least 45 percent of nitrogen 3. Removal of at least 45 percent of phosphorus.
Riverdale PSP	The PSP included an objective to deliver an integrated water management system that 'encourages reduced reliance on reticulated potable water…the re-use of alternative water, minimises flood risk, ensures waterway health and contributes towards a sustainable and green urban environment'. The PSP included a map showed the locations of sub-catchment scale stormwater treatment systems at the Davis Road East site. The PSP also included an Integrated Water Management section, which included mandatory requirements and guidelines: 1. The requirements state (among other things) that development 'must meet or exceed best practice stormwater quality treatment standards'. 2. The guidelines indicate (among other things) that: a. the design and layout of developments should 'optimise water use efficiency and long term viability of vegetation and public uses through the use of Water Sensitive Urban Design (WSUD) initiatives' b. where practical, development should 'include initiatives…to reduce reliance on potable water and increase the utilisation of storm and waste water, contributing to a sustainable and green urban environment'
Wyndham Planning Scheme Amendment C176, 13 November 2014.	This amendment (among other things), incorporated the Riverdale Precinct Structure Plan in the Wyndham Planning Scheme.
Planning Permit WYP 6217/12, 14 November 2014.	<u>Condition 1</u> required the preparation of a Stormwater Management Strategy, to the satisfaction of Melbourne Water and Wyndham City Council, that considers (among other things): 1. Street-scale diversion of stormwater into planted areas 2. Harvesting stormwater to irrigate public open space 3. Enhancing liveability by reducing hard surfaces and increasing green space 4. Increased use of water sensitive urban design. <u>Condition 14 (c)</u> required that residential and commercial buildings must include fittings allowing recycled water to be used. <u>Condition 29</u> required that urban stormwater be managed in accordance with the BPEMG. <u>Condition 88</u> required the developer to enter into an agreement with the water service provider for the provision of recycled water.
Stormwater Management Strategy, January 2015.	This strategy was prepared in response to condition 1 of planning permit WYP 6217/12. It sets out a strategy to collect stormwater from storms up to the 1 in 5 year average recurrence interval event via a piped underground drainage system and treat the stormwater to meet the BPEMG targets using four sub-catchment scale treatment units.

Source: original table

The influence of these statutory tools on WSUD practices is discussed below.

Influence of Statutory Land Use Planning on WSUD Practices

This section will firstly describe findings about the influence of SLUP on WSUD practices generally and, secondly, describe findings about the influence of statutory planning on the four components of WSUD practice identified in this thesis.

The interviewees were asked to rate the influence of SLUP on the implementation of WSUD practices generally, and on the implementation of the components of WSUD practice. The responses from the interviewees are shown in Table 7-11, following:

Table 7-11: Responses to Rating-scale Questions about the Influence of Statutory Land Use Planning at Davis Road East

Interviewee	Influence on the Adoption of WSUD Practices	Influence on the Urban Stormwater Management Component	Influence on the Urban Water Cycle Component	Influence on the Urban Water Infrastructure Component	Influence on the Urban Design Component
I	Strongly encouraging	Strongly encouraging	Strongly encouraging	Strongly encouraging	Strongly encouraging
J	Neither encouraging or discouraging	Encouraging	Neither encouraging or discouraging	Neither encouraging or discouraging	Neither encouraging or discouraging
K	Strongly encouraging	Strongly encouraging	Encouraging	Encouraging	Strongly encouraging
L[91]	Neither encouraging or discouraging	Discouraging	Neither encouraging or discouraging	Neither encouraging or discouraging	Neither encouraging or discouraging
M	Strongly encouraging	Strongly encouraging	Neither encouraging or discouraging	Encouraging	Strongly encouraging
N	Strongly encouraging	Encouraging	Encouraging	Encouraging	Neither encouraging or discouraging
O	Preferred not to answer question	Preferred not to answer question	Preferred not to answer question	Preferred not to answer question	Preferred not to answer question
P	Strongly encouraging	Strongly encouraging	Neither encouraging or discouraging	Encouraging	Neither encouraging or discouraging
Q	Preferred not to answer question	Preferred not to answer question	Preferred not to answer question	Preferred not to answer question	Preferred not to answer question

General Findings About Influence of Statutory land Use Planning on WSUD Practices

The interviewees generally rated the influence of SLUP on the adoption of WSUD practices at Davis Road East as strong. Table 7-12 summarises their ratings:

[91] Interviewee L was interviewed twice.

Table 7-12: Responses to Question about the Influence of Statutory Land Use Planning on the Adoption of WSUD Practices at Davis Road East

Response	Number of responses
Strongly encouraging	5
Encouraging	0
Neither encouraging or discouraging	2
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	2

The interviewees who provided *strongly encouraging* responses emphasised the mandatory nature of SLUP requirements related to WSUD, particularly the stormwater treatment requirements in the BPEMG referenced by Clause 56.07 of the Wyndham Planning Scheme. Typical remarks were that 'You must do what's required for your development, which is treat to best practice, yes' (interviewee I) and 'the statutory planning process is statutory. So, you know, conditions have to be complied with and so if there's a condition in the permit that refers to something that the developer needs to do, then they have to do it, that's where it helps' (interviewee K). In contrast, two interviewees suggested that SLUP neither encouraged or discouraged the adoption of WSUD practices. Interviewee L suggested that SLUP only considers a small part of the WSUD concept, so that 'all the statutory stuff, it was a very narrow band in terms of just looking at stormwater management for a receiving water objective. That's the only thing that it drove and that's been in place for 15 years'. Interviewee J further suggested that the implementation of WSUD practices is a process that includes multiple actors working over an extended period, the scope of which extends beyond SLUP: 'water sensitive urban design in your terminology is broader and it's a big thing. It requires a whole range of things to occur, so getting back to statutory planning, it forms one little element of the bigger picture in any given time'. It appears that the *Neither encouraging or discouraging responses* reflected an expansive view of the WSUD concept and the process needed to implement it. While acknowledging the range of actors and processes involved in implementing WSUD, the evidence indicates that the mandatory nature of the WSUD provisions in SLUP was critical to the adoption of the WSUD practices that were implemented at Davis Road East[92].

The inclusion of explicit stormwater treatment targets did provide clear guidance, which helped to influence WSUD practices. The stormwater treatment assets at Davis Road East were designed to meet these targets[93], so that 'you have things like the best practice management guidelines to set the target levels that developers need to comply with' (interviewee J) and 'the main one for us are those targets, the nutrient reduction targets that are spelled out in the BPEM guidelines' (interviewee M). A potential adverse consequence of targets was identified by interviewee L, who suggested that the inclusion of targets for stormwater management could lead to other aspects of WSUD being neglected: 'people just would gravitate down to those targets that we mentioned before[94]. So inadvertently the attention just focuses back on those'. This comment indicates that interviewee L did consider that targets influence WSUD practices, but was concerned about the possibility of aspects of WSUD practice not explicitly addressed by targets being neglected.

The document analysis and the interviews indicated that the BPEMG targets influenced strategic stormwater planning for a large part of the West Growth Corridor, and that the outcomes of this planning were adopted in the Riverdale PSP. The Growth Areas Authority initiated the preparation of a Wyndham North Stormwater Management Strategy (Spiire Australia 2013), which investigated stormwater management options in an area of over 4,500 hectares subject to four PSPs, including the Riverdale PSP. This Strategy states that Melbourne Water required stormwater to be treated in accordance with the BPEMG (Spiire Australia 2013). Melbourne Water participated in the development of this strategy and, as interviewee M said, 'received draft versions of the report and made comment on that and critiqued it, and that sort of added to the finalisation of that…Wyndham North Stormwater Management Strategy'. The findings of the Wyndham North Stormwater Management Strategy informed a Melbourne

[92] The range of WSUD practices adopted at Davis Road East was less extensive than was adopted at Coburg Hill. Nonetheless, the mandatory nature of statutory land use planning was a vital influence on those WSUD practices that were adopted at Davis Road East.
[93] Footnote 72 discusses how the ability of stormwater treatment systems to comply with the relevant targets is assessed in Victoria.
[94] That is, the stormwater treatment targets in the BPEMG.

Water 'Developer Services Scheme'[95] which considered how to provide, and fund, stormwater management services for urban development in the Davis Creek catchment. Complying with the BPEMG is also a key requirement for Melbourne Water's Development Services Schemes: 'that's a fundamental requirement of our scheme[96]. Probably that and flood control are the two main objectives that we're trying to achieve with our schemes', according to interviewee M. The Wyndham North Stormwater Management Strategy and the Developer Services Scheme identified a sub-catchment scale approach to stormwater treatment, which would meet the BPEMG targets. This approach was adopted in the Riverdale PSP, which included stormwater treatment assets at this scale. Interviewee M explained that:

> So what we were heading towards with this design was that we would have an aligned position, and now I'm showing you the plan of our drainage scheme works overlaid on the precinct structure plan, the Riverdale one I think it is. So what you can see is our works, for instance here…the wetlands along Davis Creek…and you can see that hopefully in the majority of cases that the PSP is consistent in that we've got land allocated or set aside for those works…So that's our goal and we meet and provide information to the MPA[97] to say, well this is Melbourne Water's expectations or requirements, I guess, or what's needed for servicing urban development and we would strongly advise you or recommend that you can put this into the PSP.

This comment indicates that there was a clear nexus between the strategic stormwater planning and the Riverdale PSP. Thus, the BPEMG influenced strategic stormwater planning, which identified the sub-catchment scale treatment regime that was adopted in SLUP for Davis Road East.

The preceding discussion indicates that the development and finalisation of the Riverdale PSP was lengthy. According to interviewee I, 'the Riverdale PSP…was in a draft in 2012, Melbourne Water fed into that process'. The initial version of the Riverdale Precinct Structure Plan was published in 2013, and the final version was released in 2014. The permit approving the subdivision of Davis Road East was issued in November 2014. The complete SLUP process spanned a period of years. This protracted timeline had consequences for the use of decentralised approaches to WSUD at Davis Road East.

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[95] Developer Services Schemes, also known as Drainage Schemes, are master plans for the stormwater drainage infrastructure for new urban developments. The cost of the infrastructure is recovered from developers. Further information is available from www.melbournewater.com.au/Planning-and-building/schemes/Pages/Scheme-maps-and-contribution-rates.aspx. Developer Services Schemes are prepared by Melbourne Water, using its powers under the *Water Act 1987* (Vic) (interviewee M).

[96] This was the response to questions about the influence of the BPEMG.

[97] Metropolitan Planning Authority.

Interviewee N indicated that the developer had initially considered using decentralised WSUD measures throughout the entire 234 hectare Grove project, including the 75 hectare Davis Road East site. However, the developer was concerned that the already lengthy statutory planning process could be further extended by the time taken to consider decentralised WSUD infrastructure at Davis Road East and thus decided to confine the investigation of innovative, decentralised WSUD approaches to that part of the Grove outside Davis Road East.

This statement is consistent with the comment from interviewee L that the developer 'then basically drew a line at Davis Road and said well we'll go along and actually meet what are the sort of kind of regulatory requirements on the east and investigate going above and beyond on the west'. These comments indicate that the developer had an initial interest in considering innovative, decentralised WSUD practices at Davis Road East, but the lengthy SLUP process acted as a disincentive for the developer to pursue this.

The preceding discussion considered the influence of SLUP on the adoption of WSUD practices broadly, without considering the specific components of WSUD practice in great detail. The following discussion examines the influence of SLUP on the four components; urban stormwater management; urban water cycle; urban water infrastructure and urban design.

<u>Findings About the Components of WSUD Practice</u>

Urban Stormwater Management

The interviewees rated the influence of SLUP on the urban stormwater management component of WSUD practice at Davis Road East as generally strong. Their responses are shown in Table 7-13:

Table 7-13: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Stormwater Management Component of WSUD Practice at Davis Road East

Response	Number of responses
Strongly encouraging	4
Encouraging	2
Neither encouraging or discouraging	0
Discouraging	1
Strongly discouraging	0
Preferred not to answer question	2

When discussing the reasons for the *strongly encouraging* and *encouraging* responses, interviewees referred to the explicit, mandatory stormwater management targets specified by the BPEMG. Interestingly, the interviewee who provided the *discouraging* rating did consider that SLUP requires stormwater treatment but, to them, the requirements in the BPEMG do not foster innovative approaches to WSUD. According to interviewee L, the SLUP system 'does an excellent job in terms of meeting receiving water objectives targets, but I think it reverts to the traditional approach of achieving that at an end of line process…in a perverse way it kind of then discourages the ability to actually get it back out into your urban fabric'. Thus, this interviewee did not dispute that SLUP influences urban stormwater management: their discouraging rating was associated with what they identified as the possibility that targets stultify the implementation of WSUD practices, beyond end of line stormwater treatment.

Urban Water Cycle

The interviewees rated the influence of SLUP on the urban water cycle component of WSUD practice at Davis Road East as modest, at best. Table 7-14 summarises the ratings for this component:

Table 7-14: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Water Cycle Component of WSUD Practice at Davis Road East

Response	Number of responses
Strongly encouraging	1
Encouraging	2
Neither encouraging or discouraging	4
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	2

Four interviewees indicated that SLUP does not influence the urban water cycle component of WSUD. This was attributed to the lack of explicit recognition of the urban water cycle in SLUP tools, in contrast to the definitive requirements for urban stormwater treatment, typified by remarks such as 'all the statutory stuff, it was a very narrow band in terms of just looking at stormwater management…That's the only thing that it drove. So it, as a driver for looking at the total water cycle, is pretty silent' (interviewee L) and 'there's no targets that have to be achieved and therefore the old question of who's going to pay and who's going to be responsible for the works that are required to achieve these things is unclear' (interviewee M). In contrast, interviewee I provided a *very encouraging* rating, because the stormwater requirements result in treated stormwater being discharged to Davis Creek. They also, however, acknowledged that SLUP does not address the broader urban water cycle. Two interviewees provided *encouraging* ratings, based on what they saw as the SLUP system's acknowledgement of the urban water cycle, but they did not identify specific urban water cycle practices that had been implemented at Davis Road East.

One aspect of the urban water cycle that was encouraged by SLUP was the use of recycled water. The planning permit requires buildings to be equipped to use recycled water and directs the developer to reach agreement with the water service provider to utilise recycled water. The supply of recycled water to greenfield development in Melbourne is now well established (Lazarova et al. 2013, 142-143) and the permit conditions helped to implement what is now largely accepted practice.

The interviews and the document analysis indicate that the recognition of the broader urban water cycle, beyond stormwater management, in the SLUP regime was confined to mandating the use of recycled water.

Urban Water Infrastructure

The interviewees rated the influence of SLUP on the urban water infrastructure component of WSUD practice at Davis Road East as moderately encouraging. The ratings are shown in Table 7-15:

Table 7-15: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Water Infrastructure Component of WSUD Practice at Davis Road East

Response	Number of responses
Strongly encouraging	1
Encouraging	4
Neither encouraging or discouraging	2
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	2

The comments supporting these ratings suggest that, despite their varied assessments, the interviewees shared a view that SLUP only influenced urban water infrastructure via the stormwater treatment requirements in the BPEMG. The sub-catchment scale treatment regime at Davis Road East was designed to comply with these requirements. According to some interviewees, the Davis Road East treatment system is relatively decentralised. The urban water infrastructure component suggests that a combination of decentralised and centralised urban water systems is desirable. Thus, interpreting the arrangements at Davis Road East as relatively decentralised logically corresponds to *strongly encouraging/encouraging* ratings. In contrast, other interviewees considered the Davis Road East system to be relatively centralised, corresponding to *neither encouraging or discouraging*. Several interviewees referred to the lack of an agreed scale to identify centralised and decentralised WSUD infrastructure. Interviewee I, for example, commented that 'there is a scale of centralised and decentralised…I would see these[98] as being potentially decentralised, instead of a large wetland, however, I am aware that, if you had tree pots and swales, that's far more decentralised'.

[98] 'These' refers to the sub-catchment scale stormwater treatment systems at Davis Road East.

Interviewee M noted that 'the interpretation of water sensitive urban design, the scale of that is very unclear'. Notwithstanding the varying responses to the rating-scale question, the interviews indicated that the urban water infrastructure at Davis Road East was configured to comply with the stormwater treatment targets in the BPEMG.

It was noted earlier in this section that the developer had an initial interest in considering innovative, decentralised WSUD practices at Davis Road East, but the lengthy SLUP process acted as a disincentive for the developer to pursue these practices. In addition to this, SLUP did not bring about the adoption of decentralised, street-scale WSUD approaches, despite these approaches being recognised in statutory planning tools. The Riverdale PSP stated that street-scale WSUD should be considered. Further, the planning permit required the preparation of a Stormwater Management Strategy, which should consider the use of street-scale WSUD infrastructure to capture and reuse stormwater at a local scale, to improve urban amenity. This Strategy had to be submitted to Wyndham City Council and Melbourne Water for approval. According to a consultant to the developer, such approaches were investigated, including efforts to quantify potential benefits: 'We had the whole costs and maintenance and all sorts of things…it was quite a business case approach' (interviewee L). Identifying and quantifying these benefits was not easy, according to interviewee N: 'there's perceived benefits, but what the actual benefits are I think it's very hard to quantify. It talks about reduced heat island effect, as an example…we engaged someone to try and model that for us and found it incredibly difficult…So that's just an example of one perceived benefit, but you just can't really quantify'. Importantly though, Wyndham City Council did not support the use of street-scale WSUD infrastructure, based on what it identified as previous unsatisfactory experiences with this type of asset, and maintenance requirements. According to interviewee P:

> we're strongly against the decentralised systems…we've had experiences and our soils out here particularly with this site in particular doesn't allow, doesn't support use of tree pits and swales within road reserves without a lot of space. So there were some recommendations put forward for raingardens and whatnot within the streetscape and again it was purely based on our experience that we kind of said we would not accept it, that the site is not suitable for that sort of application and we were strongly encouraging to just stick to the assets at the outlet.

Consistent with these remarks, the Stormwater Management Strategy that was approved by Wyndham City Council, and Melbourne Water, did not include any street-scale WSUD, but relied on the sub-catchment scale stormwater treatment referred to earlier. It is noteworthy that the Riverdale PSP and the planning permit were prepared at state government level by the Metropolitan Planning Authority, but the WSUD practices identified in response to these conditions had to be approved at local government level, by Wyndham City Council.

The evidence from the semi-structured interviews and the document analysis indicates that the influence of SLUP on the urban water infrastructure component of WSUD practice was limited to ensuring that the stormwater treatment infrastructure would comply with the requirements in the BPEMG. The lengthy time associated with the statutory planning process inhibited consideration of the use of innovative, decentralised WSUD approaches by the developer. Also, although the Riverdale PSP and the planning permit required that street-scale WSUD practices be considered, this approach was not adopted.

Urban Design

Varied assessments were made by the the interviewees about the influence of SLUP on the urban design component of WSUD practice at Davis Road East. Table 7-16 summarises their responses:

Table 7-16: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Design Component of WSUD Practice at Davis Road East

Response	Number of responses
Strongly encouraging	3
Encouraging	0
Neither encouraging or discouraging	4
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	2

The interviews suggested that the divergence in these ratings was primarily associated with different perspectives. The two Melbourne Water interviewees attributed their *strongly encouraging* ratings to the locations of sub-catchment scale stormwater treatment systems being identified in the Riverdale PSP. For example, interviewee M argued that ‘I would say that it’s strongly encouraging for the reason that it’s setting aside…the land in the precinct structure plan for the water assets’. Interviewee M similarly commented 'That's strongly encouraging and that's to do with the…PSP'. The other interviewee who provided a *strongly encouraging* rating stated that good urban design outcomes were encouraged by the PSP process. In contrast, those interviewees who provided *neither encouraging or discouraging* ratings considered that the SLUP process did not link urban water management and urban design outcomes at Davis Road East. This was attributed to reasons including the lack of street-scale WSUD measures in the development, the difficulty of including specific local urban design requirements in planning permits and developers adopting urban design principles to meet market forces, without needing statutory direction. It appears then that the interviewees who gave *strongly encouraging* ratings associated urban design outcomes with the sub-catchment scale urban water treatment systems, whereas interviewees who provided *neither encouraging or discouraging* ratings identified a lack of urban design outcomes at a more localised, street scale.

Overall, the evidence from the interviewees and the document analysis indicates that SLUP did not promote urban design outcomes at Davis Road East. Such outcomes were confined to installing the sub-catchment scale stormwater treatment systems 'so that they're a feature in the development rather than an afterthought', as interviewee P put it. The previous discussion of the urban water infrastructure component showed that SLUP did not bring about the adoption of decentralised, street-scale WSUD infrastructure. Opportunities to obtain positive urban design outcomes were also lost when the installation of decentralised, street-scale WSUD infrastructure did not proceed.

7.4.3 Conclusions from the Davis Road East Case

In total, the findings indicate that, at Davis Road East, the stormwater treatment requirements in the BPEMG referenced by Clause 56.07 of the Wyndham Planning Scheme strongly influenced the WSUD practices included in the development. These targets were taken into account in strategic stormwater management planning, which identified a sub-catchment scale stormwater treatment approach. This approach was adopted in the Riverdale PSP.

The planning permit mandated the use of recycled water in the development. SLUP recognised, and influenced, the urban water cycle component of WSUD practice to the extent that it included this requirement.

The urban water infrastructure component of WSUD practice was recognised by the SLUP system: both the Riverdale PSP and the planning permit required that street-scale WSUD practices be considered. Also, the developer initially was interested in this approach. However, despite these circumstances, decentralised, street-scale WSUD strategies were not included in the development. Firstly, the lengthy time associated with the statutory planning process acted as a disincentive for the developer to consider the use of innovative, decentralised WSUD approaches. Secondly, although the Riverdale PSP and the planning permit required consideration of street-scale WSUD practice, treatment at this scale was not adopted. References to decentralised WSUD practices being 'considered' did not carry the force needed to ensure such practices were implemented. This is particularly the case when there is a lack of guidance to determine whether WSUD assets are, relatively, centralised or decentralised[99].

The inability of SLUP to influence the urban water infrastructure component also meant that positive urban design outcomes associated with decentralised, street-scale WSUD systems were not realised. Urban design outcomes were limited to those associated with installing the sub-catchment scale stormwater treatment systems in harmony with the surrounding urban context. However, these outcomes reflected good urban design practices, rather than SLUP requirements.

Table 7-17, following, summarises factors that enhanced, or inhibited, the ability of SLUP to influence WSUD practices at Davis Road East:

[99] The only guidance about physical scale in the Victorian SLUP system is that stormwater discharged from an entire residential subdivision must meet the treatment targets in the BPEMG. According to Clause 56-07 of the VPPs 'The urban stormwater management system must be…Designed to meet the current best practice performance objectives for stormwater quality as contained in the Urban Stormwater – Best Practice Environmental Management Guidelines (Victorian Stormwater Committee 1999) as amended'. This means that urban stormwater discharged from the subdivision, as a whole, must to be treated to comply with the stormwater treatment targets in the BPEMG, before it is discharged from the subdivision. Clause 56-07 does not include further requirements about physical scale for urban stormwater treatment.

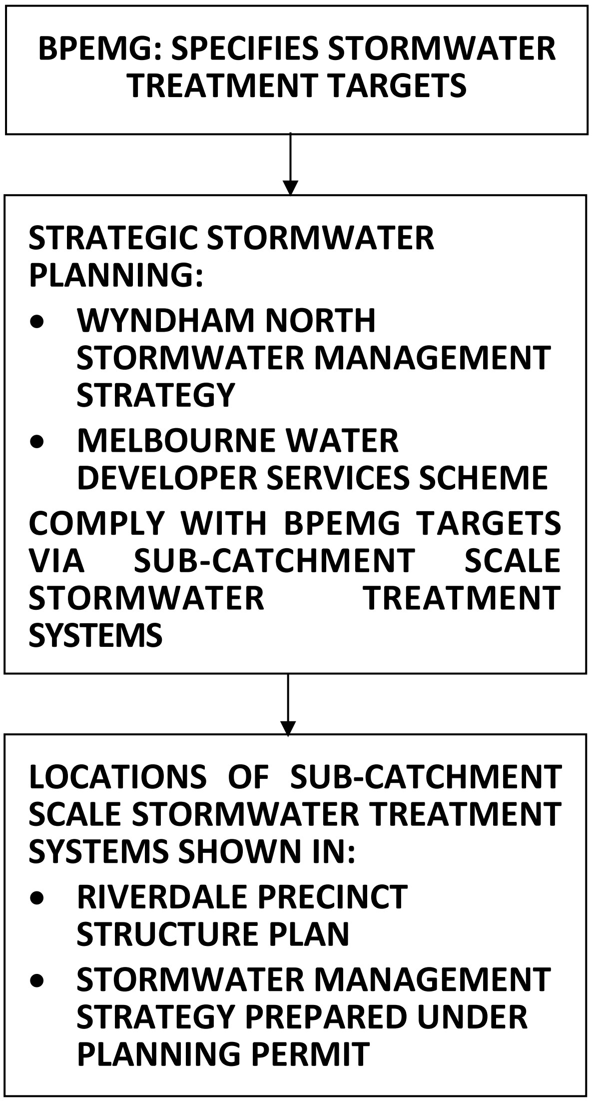
Table 7-17: Factors that Enhanced or Inhibited the Ability of Statutory Land Use Planning to Influence WSUD Practices at Davis Road East

Enhancing Factors	Inhibiting Factors
• Clear, explicit targets for urban stormwater management • Early recognition of these targets in strategic stormwater management planning • Mandatory requirements related to the use of recycled water	• Recognition of the broader urban water cycle did not extend beyond mandating the use of recycled water • Lack of mandatory requirements related to the urban water infrastructure component of WSUD practice • Lack of clarity about the physical scale at which WSUD infrastructure can be considered to be, relatively, centralised or decentralised • The protracted time taken to complete the statutory land use planning process • Difficulty quantifying the benefits associated with street-scale WSUD infrastructure • Requirements to consider street-scale WSUD measures were prepared at state government level, but proposed measures had to be approved by local government .

Source: original table

This table provides an understanding of individual factors related to the influence of SLUP on WSUD practices. However, similarly to the Coburg Hill case study, a deeper understanding is provided by examining the <u>process</u> whereby SLUP influenced WSUD practices. Schematically, the process was as shown in Figure 7-10:

Figure 7-10: Process by Which Statutory Land Use Planning Influenced WSUD Outcomes at Davis Road East



Source: original figure

This figure indicates that the stormwater management requirements in the BPEMG influenced strategic stormwater management planning processes, that is, the Wyndham North Stormwater Management Strategy and the Melbourne Water Developer Services Scheme. The sub-catchment scale treatment regime specified by these processes was then incorporated in the Riverdale PSP and the Stormwater Management Strategy prepared under the planning permit. Overall then, SLUP influenced strategic stormwater planning via the targets in the BPEMG and the outcomes of this planning were incorporated in SLUP tools (the Riverdale PSP and the Stormwater Management Strategy) that influenced WSUD practices at Davis Road East.

In contrast with the strong influence of SLUP on urban stormwater management, SLUP exerted much less influence on the other components of WSUD practice. SLUP did recognise the urban water cycle, to the extent of mandating the use of recycled water. SLUP tools did require the use of decentralised, street-scale WSUD practices to be considered. However, there were a number of impediments to the adoption of these practices, including the lengthy statutory planning timeline, the difficulty quantifying the benefits of this approach and lack of local government support. Given the absence of explicit, mandatory requirements calling for the use of decentralised WSUD practices, the impediments prevailed and such practices were not adopted. The potential urban water infrastructure and urban design outcomes associated with decentralised, street-scale WSUD infrastructure were therefore not realised. The sub-catchment scale stormwater treatment regime was not supplemented by further outcomes related to the urban water cycle, urban water infrastructure and urban design components of WSUD practice, other than the mandatory use of recycled water. This reflects an absence of explicit, mandatory requirements related to these components in the SLUP tools for Davis Road East.

7.5 Conclusions from the Victorian Case Studies

The SLUP regimes for the two Victorian cases include different sets of statutory tools. This occurred because one was a redevelopment site (Coburg Hill), while the other was a greenfield site (Davis Road East). However, an important common factor was that the SLUP regime for each site required stormwater to be managed in accordance with the requirements in the BPEMG, referenced by Clause 56.07 of the respective Planning Schemes. At Coburg Hill, these requirements were considered in the Stormwater Drainage Master Plan, which formed part of the development plan approved by the Minister for Planning. At Davis Road East, the treatment requirements in the BPEMG were considered in strategic stormwater planning, the results of which were incorporated in the Riverdale PSP and hence in the Wyndham Planning Scheme. Despite these differences in process, the stormwater treatment requirements of the BPEMG were a key determinant of the stormwater management practices that were adopted, in both cases.

Different sets of urban stormwater treatment assets were adopted at Coburg Hill and Davis Road East, in response to these treatment requirements. This is a consequence of the divergent conditions at the two development sites. Coburg Hill is a comparatively confined, high-value redevelopment site, whereas Davis Road East is a greenfield development, where stormwater treatment systems could be installed in the Davis Creek Corridor, without reducing the area that could be developed for residential use. These contrasting conditions resulted in different practices being adopted to comply with the BPEMG.

Overall, the influence of SLUP on the urban stormwater management component of WSUD practice was strong. The recognition of urban stormwater management in SLUP, with explicit mandatory targets, contrasts notably with a significantly less rigorous approach to the other components of WSUD practice.

The SLUP systems for the two cases includes some references to the broader urban water cycle, beyond stormwater management. Targets to reduce potable water consumption and wastewater volume were set for Coburg Hill, but these targets did not lead to changed urban water practices. While rainwater tanks were fitted to dwellings at Coburg Hill, these were primarily designed to reduce the volume of stormwater requiring treatment. The use of recycled water was mandated at Davis Road East. On balance, the influence of SLUP on the urban water cycle component of WSUD practice in the two cases can be described as moderate.

In both cases, SLUP lacked explicit objectives or targets for urban water infrastructure, designed to encourage the use of a combination of centralised and decentralised systems. Although infrastructure at a range of scales was installed at Coburg Hill, this approach was a cost-effective solution to meeting the stormwater treatment requirements. A further limitation of the SLUP system, in the two cases, was that it did not provide any guidance about when urban water infrastructure can be considered to be ‘decentralised’.

Explicit links between urban water cycle management and urban design outcomes were also lacking. In both cases, stormwater management systems were installed in conventional subdivision layouts. At Coburg Hill, the SLUP system did consider how to install stormwater infrastructure sympathetically within the development, but the overall design of the development was not influenced by WSUD. At Davis Road East, SLUP did not influence the urban design component of WSUD practice.

Clearly, the influence of SLUP on WSUD practices was dominated by stormwater management requirements, in both cases. The SLUP regimes generally failed to provide guidance and direction about the urban water cycle, urban water infrastructure and urban design components of WSUD, sufficient to bring about changed practices, other than the requirement to use recycled water at Davis Road East. Such outcomes as did occur for these components were largely by-products of meeting the stormwater management requirements. The strong influence of SLUP on the urban stormwater component of WSUD practice identified in the case studies, compared with the lesser influence on the other components, is also consistent with the survey reported earlier in Chapter 5.

The strong influence of specific, quantitative stormwater management targets is consistent with previous findings that explicit targets are an important part of the regulatory framework for WSUD (Taylor and Weber 2004; Kay et al. 2004; Chandler and Eadie 2006; Mouritz and Shepherd 2006; Potter and RossRakesh 2007; Corbett 2012, 2959; Tjandraatmadja et al. 2014, 81). It is also consistent with the survey described earlier in Chapter 5, where the participants reported that statutory land use controls with specific quantitative targets influence WSUD practices to a greater extent than controls that lack such targets.

Interviewees frequently referred to the specific stormwater targets mandated by Clause 56.07 of the relevant planning schemes and the strong influence of these targets. This was in stark contrast to the failure of interviewees to cite Victorian government guidance, intended to assist with the application of this clause (Victoria. Department of Sustainability and Environment 2006). The guidance emphasises an integrated water management approach, which considers all urban water streams in a holistic fashion, and refers to WSUD as a concept that 'integrates urban planning and development with the management, protection and conservation of available water sources, including urban run-off' (2006, 13). In the case studies, no evidence of any influence attributable to this guidance was observed. This contrasted with the very clear findings about the influence of the mandatory stormwater targets.

One issue where the results of case studies and the survey do not immediately reconcile is the influence of SLUP at greenfield and infill sites. The SLUP regime at Coburg Hill included a more comprehensive set of SLUP tools, compared with Davis Road East, and resulted in a more diverse set of WSUD practices being implemented. Also, the developer was a more active participant in the development of the statutory tools at Coburg Hill. Thus, in these cases, SLUP was at least as influential at a redevelopment site, compared with a greenfield site. This finding appears to conflict with the results of the survey described in Chapter 5, according to which SLUP encourages WSUD practices to a greater degree at greenfield sites, compared with infill sites. Also, the finding is not consistent with the suggestion of Wong and Eadie (2000) that there are more opportunities to employ planning tools such as zoning, land use controls and land capability assessments to encourage WSUD in relatively undeveloped catchments, compared with existing developed areas.

In the case of Coburg Hill, a site of 20.5 hectares was redeveloped and an integrated suite of statutory planning tools was employed to address a wide range of planning issues, including WSUD. During the survey, a number of participants stated that some SLUP tools include thresholds related to physical size, which typically are exceeded by greenfield developments, but not smaller-scale infill developments. However, the Coburg Hill site was sufficiently large that a set of SLUP tools could be applied to the site. This suggests that, in the Victorian SLUP system, if a redevelopment site is sufficiently large, statutory tools can be applied to it and achieve WSUD outcomes that are not disadvantaged, compared with greenfield sites. This analysis provides an explanation for the apparent conflict between the findings of the Victorian case studies, and the findings of the survey, in relation to the influence of SLUP at greenfield and infill developments.

The following chapter reports two case studies in Western Australia, which has a different SLUP regime from Victoria. Examining cases from Victoria, and cases from Western Australia, provides information about how two different SLUP systems influence the adoption of WSUD practices.

Chapter 8

WESTERN AUSTRALIAN CASE STUDIES

8.1 Introduction

This chapter describes two case studies located in Perth, the capital of the state of Western Australia. In accordance with the selection process outlined in Chapter 6, one case includes a more comprehensive set of WSUD practices than the other. However, the difference between the implementation of WSUD practices in the two cases is significantly less marked in the Western Australian examples, compared with the Victorian cases.

Section 8.2, following, provides the statutory context for the case studies. This section outlines the SLUP system in Western Australia, focusing on requirements particularly relevant to the implementation of WSUD. Sections 8.3 and 8.4 then describe the cases, including their physical settings, findings and conclusions. Conclusions are lastly drawn in Section 8.5 about the influence of the Western Australian SLUP system on the adoption of WSUD practices, based on these two case studies. This section also compares the results of the case studies with the findings of the survey described in Chapter 5.

8.2 The Western Australian Statutory Land Use Planning System[100]

The primary land use planning legislation in Western Australia is the *Planning and Development Act 2005* (WA) ('the PDA'). The purposes of the Act include the sustainable use and development of land[101]. Development means the development and use of any land, including carrying out works relating to buildings, and excavations and other works[102]. The following discussion considers how the SLUP framework, established by the PDA, regulates the use and development of land.

The broadest statutory planning tools under the PDA are state planning policies[103], which consider general planning matters, and the coordination of planning, at the

[100] This description of Western Australia's statutory land use planning system draws on Western Australia. Department of Planning (2014) and Bancroft and Gardner (2015).
[101] PDA s 3(1)(c).
[102] PDA s 4(1).
[103] State planning policies are made under section 26 of the PDA.

state-wide scale. State Planning Policy 2.9: Water Resources[104] (SPP2.9) is a component of State Planning Policy 2: Environment and Natural Resources Policy. SPP 2.9 promotes the sustainable management of water resources and requires development to take into account total water cycle management and WSUD principles. While decision makers must have due regard for SPP 2.9, and consider it while preparing SLUP tools, it is not required that decisions or policies achieve the outcomes of the SPP, or deal with all the matters included in the SPP (Bancroft and Gardner 2015, 381). Planning schemes are another important set of statutory tools. The Act provides for region planning schemes and local planning schemes. Region planning schemes[105] address regional development, while local planning schemes[106] are the primary tool that controls land use in a local government area. A local planning scheme usually covers the entire area of the local government to which it applies. Schemes generally divide the local government area into zones and reserves[107]. Zones regulate land use and the form of development.

The Metropolitan Region Scheme (MRS) is a region planning scheme that applies to Perth. The MRS defines future land uses, via zones and reservations. Local government planning schemes provide detailed plans for the parts of the MRS region they cover. In areas subject to a region planning scheme, local planning schemes must be consistent with the regional scheme[108].

Subdivision of land, including subdivision for residential development, can only take place with the approval of the Western Australian Planning Commission (WAPC)[109]. In considering subdivision application, the WAPC must consider relevant state planning policies, region planning schemes and local planning schemes, as well as other planning policies. The WAPC assesses an application in consultation with the relevant local government and public agencies. The WAPC can:

1. Approve the proposed plan

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[104] Western Australian Planning Commission *Government Gazette WA* Special Gazette No 227 State Planning Policy 2.9 Water Resources 19 December 2006, 5708.
[105] Region planning schemes are made under Part 4 of the PDA.
[106] Local planning schemes are made under Part 5 of the PDA.
[107] Reserves identify land used for public purposes, or otherwise set aside from development.
[108] PDA s 123(1).
[109] Part 10 of the PDA. This part sets out the procedures to regulate the subdivision and development of land.

2. Approve the plan, subject to conditions
3. Refuse the plan.

The PDA provides a framework to regulate land use and development, including subdivision of land for development purposes.

The publication *Better Urban Water Management* (Western Australia. Western Australian Planning Commission 2008a) provides important guidance about the Western Australian statutory framework. This document recommends that urban water planning and land use planning be linked throughout the development process. This nexus should be established at the regional scale and be maintained to the individual subdivision scale.

8.3 Case Study: Lane Gardens, Bletchley Park, Perth

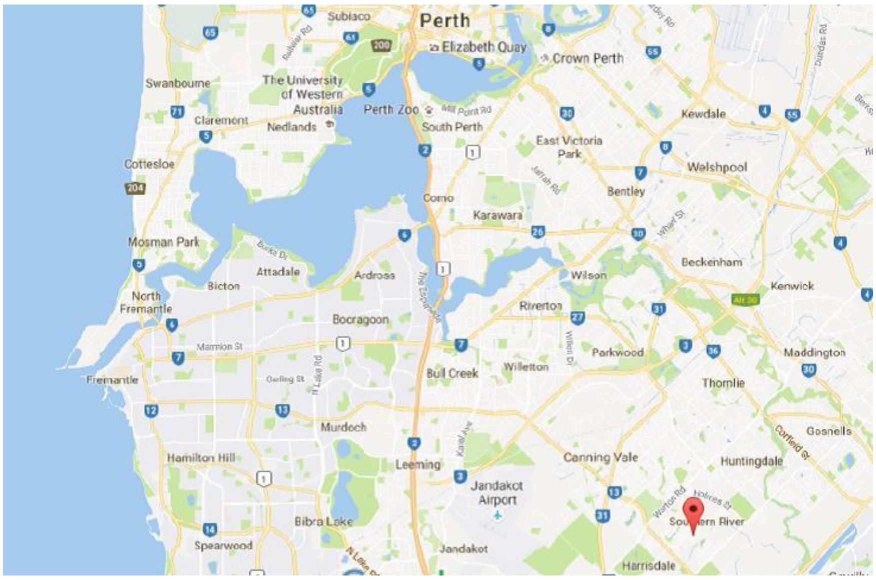
This section describes the first Western Australian case study, which includes a more comprehensive set of WSUD practices than the second Western Australian example. The case examines how SLUP influenced the adoption of WSUD practices at a residential development at Lane Gardens, Bletchley Park, Perth. Section 8.3.1 describes the development. The findings of the case study are set out in section 8.3.2 and section 8.3.3 identifies conclusions drawn from the findings.

8.3.1 Description of the Lane Gardens Development

Physical Setting

Lane Gardens is a stage of the Bletchley Park residential development, located on land formerly used for rural purposes. Bletchley Park is situated some 17 kilometres south of Perth's Central Business District, within the local government area administered by the City of Gosnells. The development site is indicated by the marker in Figure 8.1:

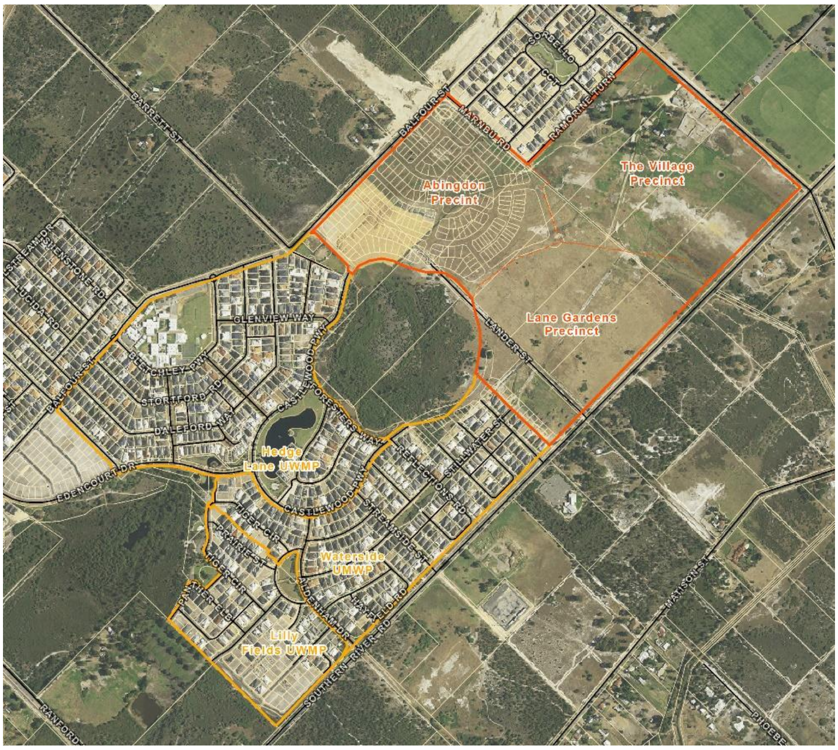
Figure 8-1: Location of the Bletchley Park Residential Development



Source: map data ©2016 Google

The Lane Gardens stage of Bletchley Park includes 211 lots for detached houses, on a 16 hectare site (interviewee R), which range in size from 388 square metres to 850 square metres[110]. The Lane Gardens site is shown in Figure 8.2:

Figure 8-2: The Bletchley Park Development, Showing the Lane Gardens Stage



Source: GHD 2014, 2

[110] Email from Western Australian Department of Planning. Copy on file with the author.

Change of Land Use to Residential[111]

Bletchley Park is located in Perth's Southern River region. Land use in this region was identified as rural in the MRS, adopted in 1963 to provide a statutory framework for development in Perth[112]. The MRS defines 'broad categories of land use that local governments use to create more detailed town planning schemes' (Hill Jr 2005, 139). Although significant changes in Perth's urban form were suggested when a Corridor Plan for Perth was released in 1970 (Western Australia. Metropolitan Region Planning Authority 1970), this plan did not consider urbanisation of Southern River, due to its low-lying, poorly drained nature (Western Australia. Western Australian Planning Commission 2001, 9). However, a review of the Corridor Plan during the mid-1980s recommended changes to Perth's urban corridors, including part of Southern River being nominated for future urban development (Western Australia. Western Australian Planning Commission 2001, 9-13). The extension of Perth's south-east urban corridor to include Southern River was proposed in the 1990 publication *Metroplan: a planning strategy for the Perth metropolitan region* (Western Australia. Department of Planning and Urban Development 1990). The MRS was amended in 1993[113], to change the zoning of most of Southern River to Urban Deferred, indicating its suitability for future urban development. The Western Australian Planning Commission endorsed a Southern River/Forrestdale/Brookdale/Wungong District Structure Plan (2001), to (among other things) guide amendments to the MRS and local planning schemes to support urban development.

[111] At the time of writing, many of the lots in Lane Gardens had been sold, a substantial number of houses had been completed and the construction of further houses was underway, but development on other parts of the site had not commenced. Importantly though, the civil engineering works for the subdivision were complete and 'all of the water sensitive urban design components, drainage components, streets and public open spaces are complete' (interviewee R).

[112] The MRS was made in accordance with the *Metropolitan Region Town Planning Scheme Act 1959* (WA). The PDA consolidated this Act, the *Town Planning and Development Act 1928* (WA) and the *Western Australian Planning Commission Act 1985* (WA) into a single Act. Part 4 of the PDA provides for the MRS to continue in force, as if it were a region planning scheme made under that part.

[113] The amendment was affected by MRS Amendment No. 927/33. Advice of the proposed amendment was gazetted in August 1993 (Western Australia, *Western Australian Government Gazette,* No. 114, Friday 20 August 1993, 4528-4529) and the adoption of the final amendment was gazetted in March 1994 (Western Australia, *Western Australian Government Gazette,* No. 34, Friday 18 March 1994, 1118-1119).

The City of Gosnells determined that planning for the urban development of the Southern River Region should proceed via a series of discrete 'precincts', with each precinct having a separate 'Outline Development Plan'. Decisions taken in accordance with this process by the Western Australian Planning Commission and the City of Gosnells resulted in the land for the Bletchley Park development being rezoned from Urban Deferred to Urban in the MRS and from Rural to Residential Development in the City of Gosnells Town Planning Scheme No. 6[114]. The Bletchley Park site was the subject of the Southern River Precinct 2 Outline Development Plan. This plan provides the statutory planning framework to guide the development and subdivision of Bletchley Park.

8.3.2 Findings

This section describes:

1. The WSUD practices included in the development
2. The SLUP tools that influenced the adoption of WSUD practices
3. The influence of these tools on the implementation of WSUD practices.

WSUD Practices Included in the Development

Lane Gardens incorporates a range of WSUD practices, which were identified by reviewing documents related to the development and the semi-structured interviews. These practices include:

1. The installation of a stormwater management system designed to, firstly, retain and infiltrate the stormwater runoff generated by the '1-year 1-hour average recurrence interval' (1-year 1-hour ARI) storm[115], as close to source as possible and, secondly, to maintain pre-development peak stormwater flow rates and

[114] Town Planning Scheme No. 6 was made under the *Town Planning and Development Act 1928* (WA). Part 5 of the PDA deals with local planning schemes. Part 5 provides for town planning schemes made under the *Town Planning and Development Act 1928* (WA) to continue in force as local planning schemes under that part.

[115] The 1-year 1-hour ARI storm refers to the maximum rain that falls over a period of one hour, with an average interval of a year between these one-hour events. The design of the stormwater system at Lane Gardens assumed that the 1-year 1-hour average recurrence interval storm is equivalent to 16 millimetres of rain falling in one hour (GHD 2014; Essential Environmental 2014).

volumes for the 1 year, 5 year and 100 year average recurrence interval storm events. This system incorporates:

a. A soakwell[116] for each house lot, which collects stormwater runoff from that lot. The stormwater percolates out of these soakwells into the sandy subsoils that underlie Bletchley Park. Soakwells serving lots with areas greater than 350 square metres can collect the stormwater runoff generated by the first 16 millimetres of rain (that is, rain equivalent to the 1-year 1-hour ARI storm), whereas the soakwells serving lots with areas less than 350 square metres can collect the stormwater runoff generated by the first seven millimetres of rain[117].
b. The collection and treatment of stormwater runoff from road reserves in raingardens located within the reserves. The size of these raingardens equals 2 percent of the area that drains to them. They have the capacity to collect and treat the stormwater runoff generated by the 1-year 1-hour ARI storm. Figure 8-3 shows one of these raingardens.
c. The collection and treatment of stormwater runoff generated by the 1-year 1-hour ARI storm, which cannot be treated by the soakwells or raingardens, in biofilters located in public open space[118]. An example of one of these biofilters is shown in Figure 8-4.
d. A piped stormwater drainage system in road reserves that conveys runoff from the 5-year ARI storm to basins in public open space, which discharge at set rates to the living stream described in (3) below.
e. The use of overland flow paths to direct runoff from the 100-year ARI storm, which exceeds the capacity of the piped drainage system, to the living stream.

[116] A soakwell is 'a cylindrical concrete tank with angled holes in the side walls and a sizeable hole in the base that allows the water to soak into the soil' (City of Gosnells n.d., 1).

[117] Housing lots with areas greater than 350 square metres can accommodate larger soakwells than smaller lots. Therefore, larger soakwells that collect more stormwater runoff are installed in larger lots and smaller soakwells that collect less runoff are installed in smaller lots.

[118] The topography of the development and the presence of some smaller housing lots, which can only accommodate soakwells that collect runoff from the first 7 millimetres of rain, means that the soakwells and raingardens cannot capture the runoff from the first 16 millimetres of rain, across the entire development. The biofilters capture and treat the runoff that is not directed to soakwells or raingardens. As shown in Figure 8-4, biofilters are engineered basins that incorporate plants and treat stormwater in a similar way to raingardens.

2. The major surface drainage channel for the site is a ‘living stream’, that is, a vegetated, non-linear structure, rather than a conventional concrete stormwater drainage structure. Figure 8-5 shows this living stream, which is integrated with a public open space corridor.
3. Lining of subsurface drains that prevent groundwater levels from rising with a material which absorbs pollutants, preventing pollutant-rich groundwater being discharged from the site[119].
4. Water conservation measures in public open space, including using locally sourced groundwater for irrigation, instead of using potable water from the centralised supply system; selecting low water-use species for landscaping; and minimising turf areas.

Figure 8-3: Raingarden, Lane Gardens

Source: Photograph by the author

[119] The Lane Gardens site is located on sandy soils, with groundwater close to the surface. Groundwater levels tend to rise as urban development takes place, because the additional impermeable surfaces cause increased runoff to enter the groundwater table. This can be prevented by installing subsurface drains, to capture rising groundwater and discharge it from the site. Such drains were installed at Lane Gardens. Also, Lane Gardens is located on a former agricultural area, with the likelihood that animal wastes and nutrient applications polluted the groundwater. The subsurface drains at Lane Gardens are lined with a material that absorbs pollutants. This prevents pollutants mobilised by rising groundwater entering the drains and being discharged from the site.
This discussion is based on information from the document analysis and the interviews.

Figure 8-4: Biofilter in Public Open Space Corridor in Lane Gardens

Source: Photograph by the author

Figure 8-5: Living Stream in Public Open Space Corridor in Lane Gardens

Source: Photograph by the author

Statutory Land Use Planning Tools

The document analysis and the semi-structured interviews identified a number of SLUP tools that influenced the adoption of WSUD practices at Lane Gardens. These tools, and the requirements related to WSUD in each tool, will now be considered.

State Planning Policy and *Better Urban Water Management*

As noted earlier, State Planning Policy 2.9: Water Resources (SPP 2.9) requires development proposals to consider total water cycle management and WSUD principles. *Better Urban Water Management* (Western Australia. Western Australian Planning Commission 2008a) provides guidance about the implementation of SPP 2.9. Importantly, this publication recommends that a 'local water management strategy' be prepared at the local planning stage of development[120] and an 'urban water management plan' be prepared at the subdivision stage.

City of Gosnells Town Planning Scheme No. 6

The City of Gosnells Town Planning Scheme (TPS) No.6 requires an 'Outline Development Plan' to be prepared for land zoned Residential Development, before Council will support development or use of the land. The Scheme also states that requirements in an approved Outline Development Plan will be adopted in the Scheme. Thus, such requirements gain statutory force.

Local Water Management Strategy for Bletchley Park (2005) and Local Water Management Strategy Amendments (2014)

A local water management strategy for Bletchley Park (dated 2005) was prepared, which formed part of an Outline Development ('OPD') adopted by the City of Gosnells in 2006, to guide development of the Bletchley Park site. The strategy identified objectives to protect the urban water cycle. These related to water conservation, stormwater management and water quality management. The strategy identified, in general terms, urban water infrastructure to meet these objectives. This infrastructure included decentralised systems, designed to capture and infiltrate stormwater locally.

An amended ODP was adopted in 2014, which clarified urban planning and urban water management arrangements for the final two development stages in Bletchley Park (from a total of six). Lane Gardens was one of these final stages. The amended ODP included a set of local water management strategy amendments (2014). The urban water regime

[120] *Better Urban Water Management* states that 'local planning' refers to areas less than 300 hectares, where statutory land use planning tools include local planning scheme amendments, local structure plans and outline development plans (Western Australia. Western Australian Planning Commission 2008a, x).

in these amendments closely resembled those in the 2005 strategy. However, the amendments provided more detail about measures to infiltrate high stormwater flows as close to source as possible; described the conversion of the main drain serving the final stages into a living stream; and required treatment of groundwater discharges.

While the City of Gosnells approved the local water management strategy and the 2014 amendments, it relied on advice from the Western Australian Department of Water that the Department was satisfied with these documents.

Subdivision Approval and Urban Water Management Plan

The 2014 local water management strategy amendments required subdivision proposals to be supported by an urban water management plan. Also, the Western Australian Planning Commission's statutory approval of the Lane Gardens subdivision was conditional on an urban water management plan being approved by the City of Gosnells, prior to subdivision commencing. The approval further required this plan to be consistent with the 2014 amendments, and that engineering drawings be approved by Gosnells, showing how the plan's urban water system would be constructed.

An urban water management plan was prepared to meet these obligations and approved by the City of Gosnells in 2014. The plan adopted the objectives and strategies in the 2014 local water management strategy amendments, while providing detailed technical guidance about the urban water infrastructure. Capture and local infiltration of stormwater was a particular focus of the plan, which also included detailed specifications for the living stream.

To summarise, the Lane Gardens development was subject to a set of SLUP tools that required urban water management to be considered at key steps in the development process. Specifically, plans were prepared that considered urban water management arrangements for Bletchley Park as a whole (the 2005 local water management strategy); for the final two stages of Bletchley Park (the 2014 local water management strategy amendments); and for the Lane Gardens subdivision (the 2014 urban water management plan). A strong, consistent theme in these plans was local capture and infiltration of stormwater. The incorporation of a living stream in the development was an important feature of the local water management strategy amendments and the urban water management plan.

The SLUP tools are also summarised in Table 8-1, following:

Table 8-1: Statutory Land Use Planning Tools that Influenced WSUD Practices at Lane Gardens

Statutory Land Use Planning Tool	Requirements Related to WSUD Practices
State Planning Policy 2.9: Water Resources	This policy requires land use planning to contribute to the sustainable management of Western Australia's water resources. Section 5.4(i) requires land use planning to 'Take into account total water cycle management and water-sensitive urban design principles'. These principles (Schedule 4) emphasise management of the water cycle as a whole and the integration of urban water management with the built form.
Better Urban Water Management (Western Australia. Western Australian Planning Commission 2008a)	This publication 'provides guidance on the implementation of *State Planning Policy 2.9 Water Resources*' (Western Australia. Western Australian Planning Commission 2008a, vii). It recommends that land use and water planning should be linked during the development process, including the preparation of a 'local water management strategy' at the local planning stage and the preparation of an 'urban water management plan' at the subdivision stage. The publication states that urban water planning should consider: 1. Water conservation and efficiency 2. Water quantity management 3. Water quality management.
City of Gosnells Town Planning Scheme No. 6.	Clause 7.2.1 of the City of Gosnells Town Planning Scheme No.6 requires an Outline Development Plan to be prepared for land zoned Residential Development, before Council will recommend subdivision or issue planning approval for development or use of the land. Clause 7.7.3 (d) of the Scheme states that requirements in an approved Outline Development Plan will have the same effect as if they were in the Scheme. Thus, such requirements have statutory force.
Local water management strategy for Bletchley Park (2005)	This local water management strategy (LWMS) is a component of an Outline Development Plan adopted by the City of Gosnells in 2006, to guide the development of the Bletchley Park site. The LWMS identifies the following urban water management issues and corresponding strategies: <u>Water conservation: reduce potable water consumption</u> 1. Maximise stormwater reuse 2. Limit potable water use outside homes and buildings. <u>Stormwater management: maintain total water cycle balance</u> 1. Where practical, retain stormwater runoff generated by the 1-year 1-hour average recurrence interval storm close to the source. 2. Attenuate peak flows from the 10 year and 100 year average recurrence interval storms to pre-development levels. <u>Water quality management: maintain surface and groundwater quality relative to pre-development conditions</u> Use structural controls such as swales[121] to minimise potential pollution of stormwater runoff and groundwater. <u>Groundwater management: maintain natural groundwater levels.</u> Design the subsoil drainage system to maintain groundwater levels The LWMS identifies, in general terms, the engineering measures to implement these strategies. A key part of these measures includes using a combination of infiltration pits, and vegetated swales and basins, to achieve local capture and infiltration of stormwater.
LWMS amendments, February 2014.	This document formed part of amendments to the Outline Development Plan, which were adopted by the City of Gosnells in 2014. These amendments clarified urban planning and urban water management arrangements for the

[121] In Western Australia, 'swales' is a term used to refer to what are commonly described as 'raingardens' in other jurisdictions. The term swales is used in Table 8.1, consistent with the source documents, but raingardens is used to refer to these installations elsewhere in this thesis. Figure 8-3 shows a raingarden at Lane Gardens. Compare this with Figure 7-3, which shows a raingarden at Coburg Hill in Victoria.

	final two of the six development stages in Bletchley Park. One of these final two stages was Lane Gardens. While the urban water management arrangements in the LWMS amendments closely resemble those in the 2005 LWMS, the LWMS amendments: 1. Specify that peak flows from the 1 year, 5 year and 100 year average recurrence interval storms should be attenuated to pre-development levels. 2. Provide more detailed information about the combination of soakwells, roadside swales and bio-retention basins in public open space, designed to achieve local capture and infiltration of stormwater. 3. Describe the conversion of the main surface drain serving the final development stages into a 'living stream', integrated with public open space. 4. Describe lining of the subsurface drainage system, used to prevent increases in groundwater levels, with a material to absorb pollutants. The LWMS amendments required the subdivision and development of an area to be supported by an urban water management plan.
Subdivision approval for Lane Gardens (Western Australian Planning Commission Application Number 148832, issued on 14 February 2014)[122]	Condition 14 of the approval states that an urban water management plan is to be prepared and approved by the City of Gosnells, prior to subdivision works commencing, and that the plan must be consistent with any approved local water management strategy.
Urban water management plan for Lane Gardens, November 2014	This is a technical report that describes the engineering measures that will be used to implement the urban water management arrangements described in the LWMS amendments, in the Lane Gardens subdivision. It adopts the objectives and strategies in the LWMS amendments, while providing detailed technical guidance about the design of devices such as soakwells, swales, subsoil drains and the living stream.

Source: original table

The influence of these statutory tools on WSUD practices is discussed below.

The Influence of Statutory Land Use Planning on Water Sensitive Urban Design Practices

This section will, firstly, describe findings about the influence of SLUP on WSUD practices generally and, secondly, describe findings about the influence of statutory planning on the components of WSUD practice identified in this thesis.

The interviewees were asked to rate the influence of SLUP on the implementation of WSUD practices generally, and on the implementation of the components of WSUD practice. The interviewees provided the ratings shown in Table 8.2:

[122] Proposed subdivisions must be approved by the Western Australian Planning Commission under s 135 of the PDA. The Commission's approval may be subject to conditions to be carried out, before the approval becomes effective (s 138(1) of the PDA). The Commission must give due consideration to a local planning scheme that applies to the land under consideration (s 138(2) of the PDA).

Table 8-2: Responses to Rating-scale Questions about the Influence of Statutory Land Use Planning at Lane Gardens

Interviewee	Influence on the Adoption of WSUD Practices	Influence on the Urban Stormwater Management Component	Influence on the Urban Water Cycle Component	Influence on the Urban Water Infrastructure Component	Influence on the Urban Design Component
R[123]	Encouraging	Strongly encouraging	Encouraging	Encouraging	Encouraging
S	Encouraging	Encouraging	Neither encouraging or discouraging	Neither encouraging or discouraging	Neither encouraging or discouraging
T	Encouraging	Encouraging	Encouraging	Encouraging	Encouraging
U	Encouraging	Encouraging	Encouraging	Encouraging	Encouraging
W	Strongly encouraging	Strongly encouraging	Encouraging	Encouraging	Strongly encouraging
X	Strongly encouraging	Strongly encouraging	Strongly encouraging	Strongly encouraging	Strongly encouraging
Y	Preferred not to answer question	Preferred not to answer question	Preferred not to answer question	Preferred not to answer question	Preferred not to answer question

General Findings About Influence of Statutory land Use Planning on WSUD Practices

The interviews and the document analysis indicated that SLUP did encourage the implementation of WSUD practices at Lane Gardens. The interviewees rated the influence of SLUP on the adoption of WSUD practices at Lane Gardens as generally encouraging, as shown in Table 8-3:

Table 8-3: Responses to Question about the Influence of Statutory Land Use Planning on the Adoption of WSUD Practices at Lane Gardens

Response	Number of responses
Strongly encouraging	2
Encouraging	4
Neither encouraging or discouraging	0
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	1

To place the role of statutory planning in context, the interviewees were asked about the range of influences, including statutory land use plannning, which affected the implementation of WSUD practices. There was consistent support for the view that

[123] Interviewee R was interviewed twice.

SLUP was foremost amongst those influences, typified by remarks such as ‘without that statutory planning mechanism and that condition in place you wouldn't get the same outcomes’ and ‘I guess fundamentally it's[124] the primary reason why we're seeing these outcomes…So yes it’s central’ (interviewee T). Interviewee V similarly commented that ‘The way the development looks and incorporates water sensitive urban design was driven by statutory planning’ and ‘that legislation really did go a long way into turning the site from just a residential development into something that is quite well integrated into the landscape’.

The reported ability of SLUP to encourage WSUD practices was associated with the requirements to prepare a local water management strategy (LWMS) and urban water management plan (UWMP). These tools are fundamental components of the Western Australian statutory planning framework, as it relates to WSUD. The 2014 LWMS amendments set out urban water management objectives for Lane Gardens and the strategies to achieve these objectives, and the UWMP provided detailed direction about how the strategies in the LWMS amendments would be implemented. The author of the UWMP saw her role as ‘developing a design for the water sensitive urban design components of the site that complied with what the local water management strategy had committed to and would produce a liveable subdivision community’ (interviewee R). The subdivision could not proceed until an UWMP, consistent with the LWMS amendments, had been approved by the City of Gosnells, providing statutory force to the LWMS amendments and UWMP. From the perspective of the developer, the mandatory nature of the UWMP was the critical factor driving the adoption of WSUD practices. Interviewee T for example stated:

> So I guess fundamentally it's the primary reason why we're seeing these outcomes…you get your approved urban water management plan and then you can go to detailed engineering design on a stage basis from there and roll out your subdivision works in accordance with that urban water management plan. So yes it's central.

It is notable that, although LWMSs and UWMPs are integral components of the SLUP framework, the content of these plans is not rigidly prescribed. As interviewee T pointed out, the ‘urban water management plan doesn’t necessarily say it needs to be water sensitive urban design. It just says an urban water management plan’. Notwithstanding

[124] This is referring to the statutory land use planning system.

these comments, guidance for the preparation of these plans is provided by a number of Western Australian government publications, including *Better Urban Water Management* (Western Australia. Western Australian Planning Commission 2008a), *Interim: Developing a local water management strategy* (Western Australia. Department of Water 2008a) and *Urban water management plans: guidelines for preparing plans and for complying with subdivision conditions* (Western Australia. Department of Water 2008b). These documents identify urban water management issues that should be considered so, according to interviewee R:

> it's basically sort of saying you've got to demonstrate how you are attempting to reduce our water consumption per capita, you've got to demonstrate how you are managing the total water cycle balance and maintaining wetlands and things like that. So it's requiring a demonstration of what you're doing to meet each one of those objectives.

The non-prescriptive nature of the LWMS and UWMP tools means that the agencies that review them have a high degree of discretion, and have the capacity to strongly influence WSUD outcomes: 'Once you sort of commence that process, it then really falls to the specific partners involved...the Department of Water, how focussed they are on that location…and very much on the local government (interview R). At Lane Gardens, the Department of Water reviewed the LWMS amendments, in conjunction with the City of Gosnells, and the City of Gosnells reviewed the UWMP. The interviews indicated very clearly that the Department and the City of Gosnells ensured that the LWMS amendments and the UWMP identified a wide range of WSUD practices that should be adopted at Lane Gardens. According to interviewee R, 'this particular site benefited from a local government who is very willing to try new things and is very engaged with water sensitive urban design. We knew this was an area that had some nutrient issues, so the Department of Water were quite focussed on it'. The role of the City of Gosnells in using SLUP to promote WSUD practices was also emphasised by interviewee V:

> I think because the City of Gosnells have such a firm vision on what they want that they really assisted in driving this…so here it was well established that the site will need to be, I suppose, incorporating every aspect of best practice water sensitive urban design that it could. And that just made it...it gave good direction and meant that there was, I suppose, a clear path forward, which was reassuring.

Another way in which the SLUP framework encouraged WSUD practices was that it facilitated discussions between key actors. According to interviewee U, the framework allowed the Department of Water to engage with the developer and consultants, and local government, to identify and promote WSUD practices[125]. This consultative process was also described by interviewee V in the following terms: 'So consult with the City of Gosnells and consult with the Department of Water around your surface and groundwater management strategies…to find out exactly what they needed'.

The SLUP process also allowed the adoption of WSUD practices to be considered at an early stage in the development of Lane Gardens. Such early consideration of WSUD helps to implement WSUD practices: 'it is too late when it comes to the subdivision…So the statutory planning…at the early stage of the development, we need to make the right decision' (interviewee W). The initial LWMS, prepared in 2005, established a series of objectives related to WSUD for Bletchley Park as a whole, and broad strategies to meet these objectives. The 2014 LWMS amendments provided more focus on the WSUD issues that should be considered for Lane Gardens, as one of the final two stages of the Bletchley Park development. The UWMP then identified, in detail, the WSUD practices needed to meet the objectives specified in the 2014 LWMS amendments. Early recognition in the SLUP system of the need to accommodate WSUD practices was very useful, so that, for example, sufficient space was provided in road reserves to allow WSUD infrastructure to be installed. Interviewee V referred to this:

> there was already provision in the road reserve for treatment areas, there was already provision in the public open space areas for treatment zones and larger basins. But if that early work had not been done, then to ask a developer, or even a development to support and incorporate that type of design effort would be very difficult, if not impossible with the way in which that development currently sits.

The preceding discussion considered the influence of SLUP on the adoption of WSUD practices generally, without considering the specific components of WSUD practice. The following discussion examines the influence of SLUP on these components.

[125] Interviewee U did not give approval for the interview with them to be recorded. A summary of key points was made during the interview and reviewed by the interviewee. This sentence is derived from that summary.

Findings About the Components of WSUD Practice

Urban Stormwater Management

The interviewees rated the influence of SLUP on the urban stormwater management component of WSUD practice at Lane Gardens as shown in Table 8-4:

Table 8-4: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Stormwater Management Component of WSUD Practice at Lane Gardens

Response	Number of responses
Strongly encouraging	3
Encouraging	3
Neither encouraging or discouraging	0
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	1

These ratings show that, according to the interviewees, SLUP favourably influenced the adoption of urban stormwater management practices at Lane Gardens. A key factor in this influence was the clear stormwater management targets in Western Australian government guidance, which indicates that stormwater systems should be designed to:

1. Collect and infiltrate runoff from the 1-year 1-hour ARI storm into the soil close to its source[126]
2. Maintain post-development flows from 1 year, 5 year and 100 year ARI interval storms at pre-development levels[127].

The clarity of the stormwater management requirements was emphasised by the author of the UWMP: 'stormwater management is the area where we do have some fairly specific targets…there was a focus on the 1-year 1-hour event as a retention onsite

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[126] See *Better Urban Water Management* (Western Australia. Western Australian Planning Commission 2008a, 28), *Interim: Developing a local water management strategy* (Western Australia. Department of Water 2008a, 10) and *Urban water management plans: guidelines for preparing plans and for complying with subdivision conditions* (Western Australia. Department of Water 2008b, 5).

[127] See *Better Urban Water Management* (Western Australia. Western Australian Planning Commission 2008a, 28), *Interim: Developing a local water management strategy* (Western Australia. Department of Water 2008a, 10) and *Urban water management plans: guidelines for preparing plans and for complying with subdivision conditions* (Western Australia. Department of Water 2008b, 8).

requirement and then other events it's about understanding the pre-development and trying to manage the post-development peaks to a similar level' (interviewee R).

As well as managing stormwater flows, that is, quantity, the system also manages stormwater quality. The stormwater components are 'sized to reflect certain quantities, but they are fundamentally there to deal with a quality issue, because the belief is that don't let it accumulate, put it back into the ground as soon as possible and it'll be a better outcome. So I guess that's all about quality' (interviewee T).

Notwithstanding the comprehensive stormwater management regime that was adopted at Lane Gardens, the interviews who provided *encouraging*, as opposed to *strongly encouraging* ratings, did identity what they saw as limits to the extent to which SLUP influenced the adoption of stormwater management practices. For example, according to interviewee T, 'I wouldn't give it any more than encouraging…by virtue of the fact that you need to go through the process, by the conditions, by the structure'. Interviewee U considered that Lane Gardens includes reasonable, rather than ideal, stormwater management practices.

The interviews and the document analysis therefore indicated that SLUP did encourage the adoption of comprehensive urban stormwater management practices at Lane Gardens, as identified in the 2005 LWMS, the 2014 LWMS amendments and the UWMP. These practices were designed to meet stormwater management criteria set out in Western Australian government guidance.

Urban Water Cycle

The interviewees rated the influence of SLUP on the urban water cycle component of WSUD practice at Lane Gardens again as encouraging, as the responses in Table 8-5 indicate:

Table 8-5: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Water Cycle Component of WSUD Practice at Lane Gardens

Response	Number of responses
Strongly encouraging	1
Encouraging	4
Neither encouraging or discouraging	1
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	1

According to these ratings, SLUP did favourably influence the adoption of practices related to the urban water cycle, but to a lesser extent, compared with urban stormwater management. Interviewees associated this favourable influence with recognition of the urban water cycle by the statutory planning system. In the words of interviewee T 'the urban water management plan deals with stormwater and consumption water, the water demand sort of thing from future residents. So it is quite holistic'. According to the author of the 2014 LWMS amendments, 'we did look at the entirety of the water cycle because we had to, it was legislated' (interviewee V). Interviewee W also noted that '*Better Water Management*[128]…clearly mentioned that we should maintain the pre-development condition at the post-development stage. So runoff wise, groundwater wise, we're trying to maintain the pre-development conditions'. The nexus between SLUP and urban water cycle management was particularly evident in the groundwater treatment regime. The need to prevent polluted groundwater being discharged from the site was identified in the 2014 LWMS amendments and an innovative technical solution was described. This approach was then 'articulated and approved though the urban water management strategy[129], because it was identified that the groundwater in the area was nutrient high', according to interviewee T.

Fortunately, the interviews suggested reasons for the less favourable overall ratings for this component, compared with urban stormwater management. According to interviewee R for example 'in this space the objectives and the measures that

[128] This is a reference to *Better Urban Water Management* (Western Australia. Western Australian Planning Commission 2008a)
[129] In the context of this interview, 'urban water management strategy' is a reference to the UWMP.

are…applied to total water cycle management are more inclined to be sort of attempt to', associated with 'more aspirational sort of wording, rather than you will do this or these are the requirements, they tend to be more about the aspirations'. Two interviewees (S and V) both pointed to what they identified as a lack of a direct connection between SLUP and large-scale urban water planning. This view was well summarised by the comment from interviewee V that:

> from an urban water perspective you can certainly look at all those urban water requirements within your subdivision quite comfortably within the work you are doing, but I suppose a lot of those urban water requirements are influenced by what is happening in the region broadly…it is not well understood if it[130] needs to capture everything it needs to, in that larger-scale understanding of the system.

Taken together, the evidence from the semi-structured interviews and the document analysis indicates that SLUP did encourage the urban water cycle component of WSUD practice. The 2014 LWMS amendments and the UWMP do consider the urban water cycle and specify measures such as localised capture and infiltration of stormwater, which helps to mitigate the impact of urban development on the water cycle; landscaping and planting designed to reduce water demand; use of groundwater for public open space irrigation; and procedures to avoid polluted groundwater being discharged from the site.

Urban Water Infrastructure

The interviewees rated the influence of SLUP on the urban water infrastructure component of WSUD practice at Lane Gardens as shown in Table 8-6:

Table 8-6: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Water Infrastructure Component of WSUD Practice at Lane Gardens

Response	Number of responses
Strongly encouraging	1
Encouraging	4
Neither encouraging or discouraging	1
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	1

[130] That is, the statutory land use planning system.

According to these ratings, SLUP again favourably influenced the urban water infrastructure component of WSUD practice. The ratings were the same as those for the urban water cycle component.

A consistent theme in the interviews was that the guidance provided by the state government to support the statutory planning process encourages the use of decentralised systems to manage urban stormwater, but this guidance is general and not supported by explicit criteria. Thus, '*Better Urban Water Management*[131] expresses the aspiration to have stormwater systems as close to the source as possible…but the way it's worded is aspirational, it is not you have to do this' (interviewee R).

While the guidance may have been characterised as aspirational by some interviewees, the Department of Water and the City of Gosnells were influential actors in the SLUP process, and they strongly advocated for the use of decentralised urban stormwater infrastructure at Lane Gardens. The statutory planning process helped the Department of Water's role in providing advice about decentralised urban water infrastructure to be recognised (interviewee U). The City of Gosnells promoted a decentralised approach to urban stormwater management and ultimately was responsible for approving the UWMP, without which the development could not proceed. The decentralised urban stormwater system at Lane Gardens was 'really driven by the Department of Water and the City of Gosnells…those two parties are required to be consulted in terms of statutory planning…you have to get their approval and then set what they would like to achieve' (interviewee V).

One interviewee provided a *Neither encouraging or discouraging* rating. According to this interviewee, 'all those decisions have to be made at massive scales…Even at the Wungong scale…which is a couple of suburbs, you have to be at that scale or bigger to make decisions about that sort of local versus regional infrastructure'. This comment considers urban water infrastructure exclusively at a very large, centralised scale. This view is not consistent with the concept of WSUD adopted in this thesis, which incorporates a combination of centralised and decentralised urban water systems.

[131] *Better Urban Water Management* (Western Australia. Western Australian Planning Commission 2008a).

Both the document review and the interviews indicate that SLUP encouraged the adoption of decentralised urban stormwater infrastructure at Lane Gardens. This decentralised approach was described in the LWMS and UWMP documents, and was consistent with Western Australian government guidance favouring management of urban stormwater close to its source. Adoption of this at-source stormwater management regime was required by the Department of Water and the City of Gosnells, during their review of the LWMS amendments and the UWMP.

Urban Design

Table 8-7 summarises how the interviewees rated the influence of SLUP on the urban design component of WSUD practice at Lane Gardens:

Table 8-7: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Design Component of WSUD Practice at Lane Gardens

Response	Number of responses
Strongly encouraging	2
Encouraging	3
Neither encouraging or discouraging	1
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	1

According to these ratings, SLUP favourably influenced the urban design component of WSUD practice. The degree of encouragement suggested by the ratings falls between those for, on the one hand, the urban stormwater management component and, on the other hand, those for the urban water cycle and urban water infrastructure components.

These ratings are consistent with the observation that the urban form of Lane Gardens was influenced by a number of urban water management elements, including roadside raingardens, bioretention basins in public open space and a living stream. These elements, which were described in the LWMS and UWMP documents, did materially affect urban form. According to interviewee V:

> The way the development ultimately looks and incorporates water sensitive urban design was driven by statutory planning, in terms of the requirements…to deal with the two governing agencies, so the City and the Department of Water. And then once those elements were integrated into the development the form that that development took was driven by water sensitive urban design…yes it really was formed by statutory

> planning and the requirements which were obtained I suppose from your reference agencies in that planning requirement.

This process, whereby the need to accommodate WSUD elements informs urban design, is consistent with state government guidance, which recommends an 'integrated urban form and water resource design process' (Western Australia. Department of Water 2008a, 13).

The living stream, which was incorporated in Lane Gardens at the insistence of the Department of Water and the City of Gosnells, provides a strong urban design element. The living stream serves as the main stormwater drainage channel for the final stages of the Bletchley Park development. It is a former rural drain, which has been converted into a vegetated, winding watercourse integrated with public open space, as shown in Figure 8-5, instead of a traditional concrete stormwater drain. During the preparation of the 2014 LWMS amendments, 'the requirement for it, that was set by the City of Gosnells, they were determined that the site look great…The Department of Water as well would not support anything other than a landscaped living stream' (interviewee R). Thus, both the City of Gosnells and the Department used the SLUP process to promote the adoption of the living stream in Lane Gardens.

The document analysis and the interviews indicate that urban water management elements such as the roadside raingardens, biofilters located in public open space and the living stream materially influenced the urban form of the Lane Gardens development. These elements were advocated by the Department of Water and the City of Gosnells, and the nexus between urban water cycle management and urban design was consistent with state government advice.

8.3.3 Conclusions from the Lane Gardens Case

Overall then, the findings indicate that, at Lane Gardens, SLUP strongly influenced the urban stormwater management component of WSUD practice. The stormwater system was designed to meet criteria in state government guidance, issued to support State Planning Policy 2.9, Water Resources, requiring that runoff from the 1-year 1-hour ARI storm be infiltrated as close to source as possible, and that pre-development stormwater flows and volumes be maintained. A stormwater treatment system, meeting these criteria, was described in the LWMS and UWMP documents. The need to include sufficient space for stormwater treatment facilities in, for example, road reserves was also recognised early in the statutory planning process, which was essential to their adoption.

The urban water cycle component was also strongly influenced by SLUP. The stormwater management criteria encouraged infiltration close to source, which helps to maintain, or at least minimise the disruption to, the natural pre-development stormwater infiltration process. The need to manage possible mobilisation of contaminated groundwater was also explicitly acknowledged and mitigation measures were specified.

The urban water infrastructure component was likewise strongly influenced by statutory planning. In order to collect and infiltrate stormwater close to source, a combination of treatment measures were installed in individual housing lots, in road reserves and in public open space.

The urban design component was noticeably influenced by SLUP. SLUP identified a range of stormwater treatment measures in road reserves and public open space that were considered during the urban design process, and influenced urban design outcomes. The living stream was identified as a high profile and central urban design element, which was promoted by SLUP.

The factors that enhanced, or inhibited, the ability of SLUP to influence WSUD practices at Davis Road East are summarised in Table 8-8:

Table 8-8: Factors that Enhanced or Inhibited the Ability of Statutory Land Use Planning to Influence WSUD Practices at Lane Gardens

Enhancing Factors	Inhibiting Factors
• Review and approval of the UWMP and the LWMS amendments by the City of Gosnells and Department of Water, respectively • Clear criteria for urban stormwater management in state government guidance • Requirement to infiltrate stormwater close to source encouraged a decentralised approach to stormwater management • Statutory land use planning process encouraged engagement between key actors • Recognition of the urban water cycle early in the statutory land use planning process	• Lack of a connection between statutory land use planning and large-scale urban water planning

Source: original table

This table provides an understanding of individual factors related to the influence of SLUP on WSUD practices. As with the Victorian cases, it is useful to consider the broader process by which SLUP influenced WSUD practices. This is shown schematically in Figure 8-6:

Figure 8-6: Process by Which Statutory Land Use Planning Influenced WSUD Outcomes at Lane Gardens

Source: original figure

According to Figure 8.6, SLUP strongly influenced urban stormwater management, via the requirements in the 2005 LWMS, the 2014 LWMS amendments and the UWMP. These required that runoff from the 1-year 1-hour ARI storm be collected and infiltrated close to its source. They further required that post-development flows from 1 year, 5 year and 100 year ARI storms be maintained at pre-development levels. These requirements were the driving force behind the adoption of stormwater controls at a range of physical scales in housing lots, streets and in public open space.

SLUP also materially influenced the other components of WSUD practice. The stormwater controls help to maintain the natural urban water cycle, by infiltrating stormwater close to its source. The 2014 LWMS amendments and the UWMP documents also included measures to reduce potable water consumption and to avoid the discharge of polluted groundwater from the site, which also reduces the impact of the development on the urban water cycle. The urban water infrastructure at Lane Gardens includes stormwater systems of varying physical scales, and so can be considered to incorporate both centralised and decentralised systems. The urban design of Lane Gardens was noticeably influenced by the need to accommodate stormwater treatment measures in road reserves and public open space and by the inclusion of the living stream.

At Lane Gardens, SLUP significantly influenced all the components of WSUD. Also, we can identify clear linkages between the urban stormwater management component and the other three components of WSUD practice. The stormwater system allows local infiltration of stormwater, helping to minimise changes to the pre-development urban water cycle; includes a portfolio of centralised and decentralised infrastructure; and influenced the urban design of Lane Gardens.

8.4 Case Study: Wungong Precinct E, Stages 3, 4 and 5, Perth

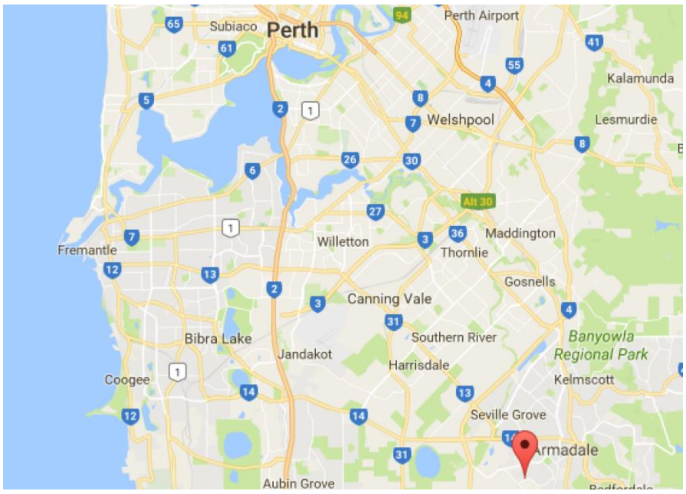
This section describes the second Western Australian case study. The case examines how SLUP influenced the adoption of WSUD practices at a residential development known as Wungong Precinct E, Stages 3, 4 and 5, in Perth. Section 8.4.1 describes the development. Section 8.4.2 sets out the findings of the case study, and conclusions are drawn from the findings in section 8.4.3.

8.4.1 Description of Wungong Precinct E, Stages 3,4 and 5

Physical Setting

Wungong is a district of 1,580 hectares, situated 25 kilometres south-east of Perth's Central Business District, within the City of Armadale. The location of Wungong within the Perth metropolitan area is indicated by the marker in Figure 8.7:

Figure 8-7: Location of the Wungong District in Perth



Source: map data ©2017 Google

Wungong is being developed in accordance with a Master Plan, which identifies a number of discrete areas, or precincts (Western Australia. Metropolitan Redevelopment Authority 2013, Appendix 2). Precinct E is a 105 hectare area, where residential development is taking place via a series of discrete stages. Stages 3, 4 and 5 cover some 9.7 hectares, including 138 housing lots. These stages were grouped, for the purposes of subdivision, and subject to a single subdivision approval. Figure 8-8 provides an aerial view of Precinct E, Stages 3, 4 and 5:

Figure 8-8: Aerial View of Wungong Precinct E, Stages 3, 4 and 5[132]

Source: map data ©2017 Google

[132] Precinct E, Stages 3, 4 and 5 is the residential development inside the black dotted line in Figure 8.8.

Change of Land Use to Residential

Along with Lane Gardens, Wungong is located in Perth's Southern River region. However, Wungong is in the City of Armadale. The geographic setting of the Southern River region and the processes associated with changing land use in this location from rural purposes to residential were described in the Lane Gardens case study, in section 8.3.1. In addition to the factors affecting Southern River generally, potential development in parts of the City of Armadale, including Wungong, is subject to a number of further constraints, such as the presence of extensive wetlands, adverse perceptions and economic factors (Davis and Farrelly 2009a, 26-27). In response to these concerns, the Western Australian government established the Armadale Redevelopment Authority (ARA), under the *Armadale Redevelopment Act 2001* (WA), to facilitate development in Armadale (Davis and Farrelly 2009a, 28). This development was referred to as the Wungong Urban Water Project. The Wungong Urban Water Redevelopment Scheme 2007 (WUWRS), prepared in accordance with the *Armadale Redevelopment Act 2001* (WA)[133], states that the area specified in the Scheme (which is the area encompassed by the Wungong Urban Water Project) is not subject to the MRS and local government planning schemes (Western Australia. Metropolitan Redevelopment Authority 2013, Clause 1.5). The WUWRS is the statutory planning instrument that regulates development in the Scheme area. The Metropolitan Redevelopment Authority (previously the Armadale Redevelopment Authority) is charged with the administering the WUWRS, including making decisions about planning applications.

The WUWRS includes a Master Plan, which specifies land uses. Most land in Precinct E is allocated to residential use (Western Australia. Metropolitan Redevelopment Authority 2013, Appendices 1 and 2).

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[133] The procedures related to the WUWRS are set out in part 4 of the *Armadale Redevelopment Act 2001* (WA). Section 29 states that a redevelopment scheme can regulate the planning and develop of a redevelopment area, and can include provisions that can be made by a local planning scheme under the PDA. The *Armadale Redevelopment Act 2001* (WA) was repealed by the *Metropolitan Redevelopment Authority Act* 2011 (WA), as of 31 December 2011. The latter Act, amongst other things:

1. Created the Metropolitan Redevelopment Authority (s 4)
2. Transferred the functions of the Armadale Redevelopment Authority to the Metropolitan Redevelopment Authority (pt 11)
3. Provided for the continued operation of the WUWRS (s 145).

8.4.2 Findings

This section describes:

1. The WSUD practices included in the development
2. The SLUP tools that influenced the adoption of WSUD practices
3. The influence of these tools on WSUD practices

WSUD Practices Included in the Development

Wungong Precinct E, Stages 3, 4 and 5 ('Wungong E Stages 3/4/5') includes a range of WSUD practices, which were identified by reviewing documents related to the development and the semi-structured interviews. These practices are:

1. The installation of a stormwater management system designed to, firstly, retain and infiltrate the stormwater runoff generated by the 1-year 1-hour ARI storm close to source and, secondly, to reduce the load of stormwater pollutants discharged from the development, compared to a traditional piped system. This system incorporates:
    a. A soakwell for each house lot, which receives stormwater runoff from that lot. The soakwells are designed to maximise infiltration to the subsoil.
    b. The collection of runoff from roads, and overflows from the soakwells, in a 'leaky' piped stormwater system, which is designed to allow localised infiltration of the stormwater. The system includes pits with large holes in their bases, which allow stormwater to soak into the soil. Figure 8-9 below shows one of these pits. The greater part of this system discharges to vegetated treatment areas in the Neerigen Brook South Main Corridor, which absorb and treat flows from storms up to the 1-year 1-hour ARI event[134].

[134]Wungong E Stages 3/4/5 includes two catchments, which drain to the Nerrigen Brook South Main Drain corridor and the Lannam Road park avenue.
The Neerigen Brook catchment is the larger. It includes 7.1 hectares of residential development and road reserve. Each housing lot includes a soakwell, as described in (a). The entire 7.1 hectare catchment is drained by the leaky stormwater system, which is designed to encourage local infiltration. Overflows from this system are directed to vegetated treatment areas in the Nerrigen Brook South Main Drain corridor, which are designed to treat and infiltrate flows from the 1-year 1-hour ARI storm.

c. Runoff from roads adjacent to the public open space corridor that adjoins the site to its south-east is directed into the corridor by overland flow[134].

d. Flows from storms exceeding the 1-year 1-hour ARI event, up to the 5-year ARI storm, are conveyed by the piped stormwater system and, in the case of very large storms, up to the 100 year ARI storm, by overland flow paths, to the major stormwater channels described in (2).

2. The development is integrated with public open space corridors designed for multiple uses, including managing stormwater. The site is bounded to the north-west by the Neerigen Brook South Main Drain (NBSMD)[135]. The NBSMD was formerly a drainage channel, which has been converted into a substantial landscaped open space corridor, incorporating a meandering channel to convey runoff from the catchment it drains. The corridor includes outlets that direct stormwater flows from Wungong E Stages 3/4/5 to vegetated treatment areas. The site is bounded to the south-east by the Lannam South 'park avenue' corridor, which is a landscaped public open space corridor that provides for stormwater conveyance. The road adjacent to the corridor is fitted with flush kerbing, so that stormwater runs off the road directly into the corridor.
3. Groundwater levels are controlled by a subsoil drainage system. The discharges from this system are directed to the vegetated treatment areas in the NBSMD. The treatment areas remove pollutants from the groundwater discharge, before it is discharged to the drainage channel.

The smaller catchment, which drains to the Lannam Road park avenue, includes 2.0 hectares of residential development and road reserve. A large part of the road reserve adjoins the park avenue and runoff from this road directly enters the park avenue via overflow flow. This allows local infiltration of this stormwater. The remaining road reserve, and the residential development, is drained by the leaky stormwater system, which encourages local infiltration. Overflows from this system are directed into the park avenue, downstream of Wungong E Stages 3/4/5.
This description is based on the document analysis and the interviews with interviewee Z.
[135]Neerigan Brook South Main Drain conveys the stormwater drainage from a substantial catchment upstream of Wungong E, Stages 3, 4 & 5, which extends beyond the Wungong Urban Water Master Plan area. The integration of major drainage channels, such as the Neerigan Brook South Main Drain, with urban development was one of the objectives of the Wungong Urban Water Project.

Figure 8-9: Pit in the Leaky Stormwater System, Wungong E Stages 3/4/5

Source: photograph by the author

Statutory Land Use Planning Tools

The document analysis and the semi-structured interviews identified a number of SLUP tools that influenced the adoption of WSUD practices at Lane Gardens. These tools, and the requirements related to WSUD in each tool, will now be considered.

State Planning Policy and *Better Urban Water Management*

These tools were described earlier in this chapter, in relation to the Lane Gardens case study, and do not need further discussion.

Wungong Urban Water Redevelopment Scheme 2007

This is the statutory tool that regulates land use in the Wungong Urban Water Project area. It includes a Master Plan that establishes land uses. The Master Plan identifies the NBSMD corridor as active open space and also sets land aside for the Lannam Road park avenue.

The Scheme divides the area it covers into thirteen precincts, and makes the development of a precinct conditional on the preparation and approval, by the Armadale (later Metropolitan) Redevelopment Authority, of a Structure Plan. A proposed Structure Plan must incorporate several environmental management plans, including a local water management strategy.

Urban Water Management Policy

This policy was adopted by the Armadale Redevelopment Authority policy to provide direction about how the urban water cycle should be considered during the preparation of structure plans and subdivision proposals. The policy required structure plans to include a local water management strategy and further required that a subdivision application be accompanied by an urban water management plan, consistent with the relevant local water management strategy. The policy also included the following stormwater treatment targets:

1. Removal of at least 60 percent of suspended solids
2. Removal of at least 60 percent of phosphorus
3. Removal of at least 45 percent of nitrogen.

The policy guided the Authority's decision making about local water management strategies and urban management management plans submitted to it for approval.

Local Water Management Strategy Precinct E (2008)

This strategy was prepared in accordance with the Wungong Urban Water Redevelopment Scheme, to allow development of Precinct E to proceed. The strategy identified objectives to protect the urban water cycle. These objectives related to managing peak stormflows (water quantity), maintaining surface and groundwater quality, and water conservation. The strategy identified, in very general terms, urban water infrastructure to meet these objectives. This infrastructure included decentralised systems, intended to allow local infiltration of stormwater. The strategy stated that the location and scale of these measures would be specified in urban water management plans prepared when areas in Precinct E were subdivided.

Precinct E Structure Plan (2009)

The Structure Plan identified land uses. The land in Stages 3,4 and 5 was allocated to residential use. Land for the NBSMD corridor and the Lannam Road park avenue was also identified.

Subdivision Approval and Urban Water Management Plan

As noted above, the preparation of an urban water management plan to accompany subdivision was required by the Urban Water Management Policy and the local water management strategy. Additionally, the Western Australian Planning Commission's statutory approval of the subdivision of Stages 3, 4 and 5 was conditional on an urban water management plan being approved by the Armadale Redevelopment Authority prior to works commencing, and the plan's requirements being included in the subdivisional works.

An urban water management plan was prepared in accordance with these stipulations and approved by the Armadale Redevelopment Authority in 2011. The plan described technical measures to implement the local water management strategy within the subdivision. Capture and local infiltration of stormwater was a central component of the plan.

In summary, the SLUP regime at Wungong E Stages 3/4/5 included a set of tools that required urban water management to be considered at specific steps in the development process. A local water management strategy was prepared to support the development of Precinct E and an urban water management plan was prepared at the subdivision stage. This process has clear parallels to that seen at Lane Gardens.

In both the local water management strategy and the urban water management plan, localised capture and infiltration of stormwater was a particularly important objective. This objective also applied at Lane Gardens.

The SLUP tools identified open space corridors that adjoin Stages 3, 4 and 5. An additional requirement, compared with Lane Gardens, was a set of stormwater treatment targets.

The SLUP tools are also summarised in Table 8-9, following:

Table 8-9: Statutory Land Use Planning Tools that Influenced WSUD Practices at Wungong E Stages 3/4/5

Statutory Land Use Planning Tool	Requirements Related to WSUD Practices
State Planning Policy 2.9: Water Resources	This policy requires land use planning to contribute to the sustainable management of Western Australia's water resources. Section 5.4(i) requires land use planning to 'Take into account total water cycle management and water-sensitive urban design principles'. These principles (Schedule 4) emphasise management of the water cycle as a whole and the integration of urban water management with the built form.
Better Urban Water Management (Western Australia. Western Australian Planning Commission 2008a)	This publication 'provides guidance on the implementation of *State Planning Policy 2.9 Water Resources*' (Western Australia. Western Australian Planning Commission 2008a, vii). It recommends that land use and water planning should be linked during the development process, including the preparation of a local water management strategy at the local planning stage and the preparation of an urban water management plan at the subdivision stage. The publication states that urban water planning should consider: 1. Water conservation and efficiency 2. Water quantity management 3. Water quality management.
Wungong Urban Water Redevelopment Scheme 2007	The Scheme includes a Master Plan that identifies land uses. The Master Plan identifies land use in the NBSMD corridor as active open space and sets land aside for the Lannam Road park avenue. The Scheme also includes a Structure Plan map that divides the area subject to the Scheme into thirteen precincts. The development of a precinct is conditional on the preparation and approval of a Structure Plan. Clause 6.8 describes the contents of a proposed Structure Plan. It states that proposed Structure Plans must be supported by a number of 'environmental management plans', including a local water management strategy.
Armadale Redevelopment Authority Urban Water Management Policy (2008)	This Armadale Redevelopment Authority policy provided direction about how the urban water cycle should be considered during the preparation of structure plans and subdivision proposals. The policy required structure plans to include a local water management strategy and further required that a subdivision application be accompanied by an urban water management plan, consistent with the relevant local water management strategy. The policy also included stormwater treatment targets, requiring: 1. Removal of at least 60 percent of suspended solids 2. Removal of at least 60 percent of phosphorus 3. Removal of at least 45 percent of nitrogen
Local Water Management Strategy Precinct E (2008)	The LWMS was prepared in accordance with the Wungong Urban Water Redevelopment Scheme, to allow the development of Precinct E. The LWMS identified the following urban water management issues and corresponding strategies: <u>Water quantity: maintain total water cycle, compared with pre-development conditions</u> 1. Maintain the 1-year 1-hour ARI volume and peak flow rates at or below existing levels 2. Maintain the 10 and 100 year ARI peak flows from the Precinct at or below existing levels. 3. Maximise stormwater infiltration opportunities 4. Install subsoil drainage to control groundwater levels. <u>Water quality: maintain or improve surface and groundwater quality</u> 1. Maintain the 1-year 1-hour ARI event post development discharge volume and peak flow rates, relative to predevelopment conditions 2. Where possible, infiltrate frequently occurring events 3. Use 'treatment train' approach to manage stormwater, including structural controls such as biofilters, retention/detention areas and swales. <u>Water conservation: maximise stormwater reuse</u> 1. Implement water efficiency and demand management measures 2. Maximise stormwater infiltration and infiltrate the 1-year 1-hour ARI event, where possible. 3. Provide a reticulated non-potable water supply pipe network. The LWMS identified, in very general terms, the engineering measures that should be used to implement these strategies. These included decentralised infrastructure, such as household soakwells, swales and stormwater systems

	intended to allow local infiltration, and the development of living stream corridors. The LWMS stated that the location and scale of these measures would be specified in UWMPs, prepared when areas within the Precinct are developed.
Precinct E Structure Plan (2009)	The Structure Plan identified land uses. The land subdivided in Stages 3,4 and 5 was allocated to residential use. Adjoining land was reserved for the Neerigen Brook and Foreshore, and the Lannam Road park avenue.
Subdivision approval (Western Australian Planning Commission Application 140432, 30 June 2010)	Condition 29 of the approval stated that a UWMP must be prepared and approved prior to the commencement of site works. Condition 30 stated that the UWMP is to be implemented as part of subdivisional works.
UWMP Wungong Precinct E Stage, 4 & 5 (2011).	This is a technical report that described engineering measures to implement the urban water regime set out in the LWMS. The stormwater treatment system included household soakwells, a leaky stormwater system and vegetated treatment areas in the NBSMD and Lannam Road park avenue corridors. This system was designed with the capacity to treat and infiltrate flows from the 1-year-1 hour ARI storm. Larger flows were designed to be conveyed by the stormwater system and overland flow to the NBSMD and Lannam Road park avenue corridors. Groundwater discharges were to be directed to the vegetated treatment areas in the NBSMD corridor.

Source: original table

The influence of these statutory tools on WSUD practices is discussed below.

The Influence of Statutory Land Use Planning on Water Sensitive Urban Design Practices

This section will, firstly, describe findings about the influence of SLUP on WSUD practices generally and, secondly, describe findings about the influence of statutory planning on the components of WSUD practice identified in this thesis.

The interviewees were asked to rate the influence of SLUP on the implementation of WSUD generally, and on the implementation of the components of WSUD. The interviewees provided the responses shown in Table 8-10:

Table 8-10: Responses to Rating-scale Questions about the Influence of Statutory Land Use Planning at Wungong E Stages 3/4/5

Interviewee	Influence on the Adoption of WSUD Practices	Influence on the Urban Stormwater Management Component	Influence on the Urban Water Cycle Component	Influence on the Urban Water Infrastructure Component	Influence on the Urban Design Component
Y	Encouraging	Neither encouraging or discouraging	Neither encouraging or discouraging	Neither encouraging or discouraging	Encouraging
Z[136]	Encouraging	Strongly encouraging	Neither encouraging or discouraging	Encouraging	Strongly encouraging

[136] Interviewee Z was interviewed twice.

AA	Encouraging	Encouraging	Neither encouraging or discouraging	Encouraging	Neither encouraging or discouraging
AB	Strongly encouraging	Encouraging	Encouraging	Discouraging	Discouraging
AC	Strongly encouraging	Strongly encouraging	Preferred not to answer question	Preferred not to answer question	Preferred not to answer question
AD	Strongly encouraging	Strongly encouraging	Encouraging	Encouraging	Strongly encouraging

General Findings About Influence of Statutory land Use Planning on WSUD Practices

The interviewees rated the influence of SLUP on the adoption of WSUD practices as summarised in Table 8-11:

Table 8-11: Responses to Question about the Influence of Statutory Land Use Planning on the Adoption of WSUD Practices at Wungong E Stages 3/4/5

Response	Number of responses
Strongly encouraging	3
Encouraging	3
Neither encouraging or discouraging	0
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	0

To place the role of statutory planning in context, the interviewees were asked about the range of influences, including statutory land use plannning, which affected the implementation of WSUD practices. The interviewees indicated that SLUP was foremost amongst those influences and was a critical factor in the adoption of WSUD practices. Typical comments were 'if it[137] wasn't very firmly driven by the Department of Water or these kind of statutory bodies, I would say it's unlikely that you would have any significant effort to provide a sustainable drainage outcome' (interviewee Y) and 'the *Better Urban Water Management* framework and the structure planning process require them to address the strategy of water sensitive urban design and… how they're going to implement WSUD and total water management' (interviewee Z).

[137]That is, the adoption of WSUD practices.

The document review and the interviews showed the ability of SLUP to influence WSUD practices was due to the preparation of a LWMS and UWMP at the structure planning and subdivision stages, respectively, in accordance with the *Better Urban Water Management* framework (Western Australia. Western Australian Planning Commission 2008a). The LWMS was a mandatory requirement under the Wungong Urban Water Redevelopment Scheme 2007 (effectively the planning scheme), and the preparation of a UWMP was a condition of the Western Australian Planning Commission's subdivision approval. The scope of the LWMS covers all of Precinct E, so that it is 'quite a high-level document. It would specify the type of systems that will be considered', as interviewee Z commented. That said, the LWMS sets out the principles and general approach to implementing WSUD and, according to interviewee AA, 'A well prepared LWMS is critical for adopting a lot of this stuff[138]'. The UWMP describes how the strategy described in the LWMS is implemented, so that 'the UWMP really says, well this is how we implement at a very detailed level, the LWMS. So, this is where these kind of structures are going, this is how they look, this is how they get designed, this is how they get maintained', as interviewee AA commented. The importance of the *Better Urban Water Management* approach in bringing about the adoption of WSUD practices was emphasised by interviewee AB. She stated that prior to this framework, WSUD had frequently been ignored during the planning process, but 'when Better Urban came along, it was much more prescriptive about at each stage of the planning process, you have to look at water resources'.

Some obstacles to the implementation of WSUD practices were also identified during the interviews. One factor was the lack of technical guidance about WSUD at the time of the development, so that 'the statutory planning process was encouraging, but the infrastructure design policies and standards were not sufficiently developed or on their journey at that point to deliver the desired planning and statutory planning outcome', according to interviewee Y. That said, interviewee Z saw this situation as providing flexibility to identify appropriate technical solutions: 'the urban water management plan…had to build upon the…LWMS to put together a series of control structures and flow control devices that would throttle flows back. But there would have been quite a

[138] That is, WSUD practices.

bit of flexibility in how that was implemented'.

Another issue noted by a number of interviewees was the large number of agencies that contributed to the development of SLUP tools, including the LWMS and UWMP for Wungong E Stages 3/4/5. These agencies had differing objectives and attitudes to WSUD. This complexity relates to the specific circumstances at this development: the NBSMD corridor is jointly vested in the City of Armadale and the Water Corporation; the Water Corporation also has statutory responsibilities related to main drainage and flood management; the then Armadale Redevelopment Authority approved the LWMS and the UWMP, while considering advice from the Department of Water, the Water Corporation and the City of Armadale; and, after the construction phase, the City of Armadale was responsible for the operation and maintenance of urban stormwater infrastructure. Interviewee AA noted that 'you think about it from a statutory point of view. It's very convoluted and you've got many different agencies getting involved'. According to interviewee AB, the number of agencies, and their varying views, hindered negotiations with the developer about the implementation of WSUD practices: 'You can't get agreement on the technologies that should be used and because you can't get a consistent approach we've got a development industry who is quite resistant to it[139]'. Importantly, the Wungong E Stages 3/4/5 development coincided with the introduction of the *Better Urban Water Management* framework in Western Australia. The interviews show that the many organisations involved in the SLUP process had not, at that time, consistent views and attitudes towards WSUD practices at Wungong E Stages 3/4/5.

While noting the lack of technical guidance that prevailed at the time of the development and the complex organisational landscape, it is clear that SLUP was the essential factor in encouraging the adoption of WSUD practices at Wungong E Stages 3/4/5. The LWMS set out WSUD principles that applied to the development of Precinct E and the UWMP specified the technologies used to give effect to these principles in the Wungong E Stages 3/4/5 development.

[139] That is, the adoption of WSUD practices.

The preceding discussion considered the influence of SLUP on the adoption of WSUD practices generally, without considering the specific components of WSUD practice. The following discussion examines the influence of SLUP on these components.

Findings About the Components of WSUD Practice

Urban Stormwater Management

Table 8-12 shows how the interviewees rated the influence of SLUP on the urban stormwater management component of WSUD practice at Wungong E Stages 3/4/5:

Table 8-12: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Stormwater Management Component of WSUD Practice at Wungong E Stages 3/4/5

Response	Number of responses
Strongly encouraging	3
Encouraging	2
Neither encouraging or discouraging	1
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	0

The interviews and the document analysis indicate that the most important factor in the design of the stormwater management system was the inclusion of specific requirements in the LWMS and the UWMP. These required that the pre-development 1-year 1-hour ARI volume and peak flow rates be maintained after development, and that local infiltration of stormwater be maximised. The stormwater system, which included decentralised elements (household soakwells, leaky stormwater system, vegetated treatment zones in the NBSMD corridor and flush kerbing adjacent to the Lannam Road park avenue) was a response to these requirements. From a technical perspective, the need to achieve local infiltration of stormwater from the 1-year 1-hour storm was particularly important. Interviewee AA stated that the design of the stormwater system was 'pretty much focused on that 1-year 1-hour sort of target' and 'that's the primary driver I guess'. Interviewee Z commented that 'there are a number of treatment trains inherent in the design' [*And that's driven by that at-source approach*?] 'Yes, yep'.

The stormwater treatment targets had little influence on stormwater management practices. The stormwater treatment regime was, in effect, deemed to have met these targets. According to interviewee Z ‘So long as you perform or install some sort of a treatment system, you’re deemed to comply’. The utility of the targets was questioned by interviewee Y, who stated that ‘They’re redundant. They’ve been superseded and we’ve moved on’. Rather than influencing the design of the urban stormwater system, the most useful contribution of these targets was encouraging pre-development monitoring of conditions at the development site. Interviewee AB stated that ‘they were helpful in that they forced things to happen that would not have otherwise happened, like predevelopment monitoring’.

The interviews and the document analysis indicate that SLUP did encourage the adoption of comprehensive urban stormwater management practices at Wungong E Stages 3/4/5, which were designed to meet specific, quantitative requirements specified in the LWMS and the UWMP. The stormwater system was also deemed to comply with the treatment targets.

Urban Water Cycle

The interviewees rated the influence of SLUP on the urban water cycle component of WSUD practice at Wungong E Stages 3/4/5 as shown in Table 8-13:

Table 8-13: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Water Cycle Component of WSUD Practice at Wungong E Stages 3/4/5

Response	Number of responses
Strongly encouraging	0
Encouraging	2
Neither encouraging or discouraging	3
Discouraging	0
Strongly discouraging	0
Preferred not to answer question	1

While the rating-scale information is limited, it suggests that SLUP did little to encourage enhanced management of the urban water cycle as a whole at Wungong E Stages 3/4/5. Typical comments were ‘there was nothing special done in terms of reducing the amount of water usage across the development as far as I could see’ (interviewee Z) and ‘the policy words were there. It was really the translation of that policy into implementation where there were barriers…we want to do these sorts of things and then when you get to the implementation side of it, that’s where it fell over’ (interviewee AB). Although the LWMS and the UWMP both refer, in general terms, to improving water conservation and efficiency, these provisions did not result in specific practices being adopted. According to interviewee Y, this can be attributed to decisions about the urban water cycle being taken at a large physical scale, which does not align with SLUP, so that 'the urban water cycle stuff needs to be resolved at more broader levels…statutory planning is too late'.

A specific urban water cycle measure identified in both the LWMS and the UWMP was the provision of a scheme to provide households with treated wastewater for non-potable uses, reducing the demand for potable water. However, this practice was not adopted: 'the original plan was for it to be a third pipe and to have all this whiz bang stuff in it, but it just turned out that it just didn't stack up economically' (interviewee Y), so that 'it's kind of fallen back to quite a centralised business as usual approach', according to interviewee AC.

Although SLUP did not lead to the adoption of specific water conservation practices, the urban stormwater system does include a range of decentralised measures that encourage local infiltration of stormwater. This approach reduces the impact of urban development on the stormwater cycle and is a positive urban water cycle outcome.

Another favourable urban water cycle outcome, mandated by SLUP, is the treatment of groundwater collected by the subsurface drainage system, to remove pollutants, via vegetated treatment areas in the NBSMD corridor. The requirement was identified in the UWMP.

The general references to water conservation and water efficiency in the SLUP system, including the LWMS and the UWMP, did not lead to the introduction of corresponding practices. A recycled water scheme was not adopted, despite being advocated by the LWMS and the UWMP. However, the urban stormwater system is designed to encourage localised infiltration, in accordance with SLUP requirements. Also, groundwater discharges to the NBSMD corridor are treated.

Urban Water Infrastructure

The interviewees rated the influence of SLUP on the urban water infrastructure component of WSUD practice at Wungong E Stages 3/4/5 as shown in Table 8-14:

Table 8-14: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Water Infrastructure Component of WSUD Practice at Wungong E Stages 3/4/5

Response	Number of responses
Strongly encouraging	0
Encouraging	3
Neither encouraging or discouraging	1
Discouraging	1
Strongly discouraging	0
Preferred not to answer question	1

The interviews and the document analysis indicate that SLUP influenced the urban water infrastructure component, via the requirement that stormwater be infiltrated close to its source. To meet this requirement, the urban stormwater management system includes elements at a range of physical scales.

The development took place when the *Better Urban Water Management* framework, and the direction it provides about matters such as at-source management of stormwater, was novel. Agencies had differing views about WSUD practices. Thus, while a decentralised approach to urban stormwater management was 'definitely what the Department of Water want…they want it at source everywhere, on every street, every corner' (interviewee Z), there 'can be a little bit of tension between what high level policy wants versus what local government is prepared to take on' (interviewee AB). According to interviewee Z, the City of Armadale did not support the use of street-scale raingardens in the development. Thus, while an urban stormwater management system with decentralised elements was adopted, the opportunity for the inclusion of further street-scale infrastructure was not realised, due to differing attitudes by agencies to WSUD practices, at that time.

Urban Design

Table 8-15 shows how the interviewees rated the influence of SLUP on the urban design component of WSUD practice at Wungong E Stages 3/4/5:

Table 8-15: Responses to Question about the Influence of Statutory Land Use Planning on the Urban Design Component of WSUD Practice at Wungong E Stages 3/4/5

Response	Number of responses
Strongly encouraging	2
Encouraging	1
Neither encouraging or discouraging	1
Discouraging	1
Strongly discouraging	0
Preferred not to answer question	1

While the rating-scale information is limited, its divergence is notable. At Wungong E Stages 3/4/5, two separate sets of urban design outcomes can be considered. These are, firstly, the integration of the residential development with the adjoining public open space corridors and, secondly, the urban form within the residential area. As expressed by interviewee AC, 'the design of the contributing urban area to that living stream, as compared to the design of the living stream itself, I suppose is two separate issues in a way'. The three *strongly encouraging/encouraging* ratings relate to what were described as favourable urban design outcomes in the public open space corridors, so that, according to interviewee Z, their 'shape, the form, the structures, that was all driven by statutory planning processes'. In contrast, the two *neither encouraging/discouraging* ratings relate to the urban form of the residential area, and views that it was not influenced by SLUP, so that 'all the land planning design was done first and then water was just tacked on at the end', as expressed by interviewee AB.

The document analysis and the interviews confirm that, within the residential area, the urban stormwater infrastructure, which includes soakwells and the leaky stormwater system, did not influence urban design outcomes. Street-scale raingardens, which would have influenced urban form, were not installed, as they were not supported by local government. Thus, the design of the residential area was not influenced by SLUP.

Turning to urban design outcomes in the NBSMD and the Lannam Street Park Avenue, the scope of the research reported in this thesis needs to be considered. Rather than considering the design of these corridors in its entirety, an examination of how the urban water infrastructure directly associated with Wungong E Stages 3/4/5 was integrated with the public open space corridors, would reflect the scope of the research, which is concerned with how SLUP influences WSUD at the subdivision scale.

Stormwater runoff from road reserves adjoining the Lannam Avenue park avenue flows directly into that public open space. This helps to achieve local infiltration of stormwater. An inspection by the author indicates that this process has little impact on amenity values, as shown in Figure 8-10:

Figure 8-10: Lannam Road Park Avenue, Adjacent to Wungong E Stages 3/4/5

Source: Photograph by the author

The integration of the residential area with the NBSMD is more complex. Stormwater, which cannot be infiltrated locally via the household soakwells and leaky stormwater system, is directed into vegetated treatment areas located in the NBSMD. These areas are part of the suite of measures used to comply with the requirement to retain and infiltrate stormwater from the 1-year, 1-hour ARI storm. They also treat groundwater collected by the subsoil drainage system. An inspection by the author indicated that, while some of the outlets and associated treatment areas can be described as well integrated with the NBSMD corridor (Figure 8-11), others could not be described in these terms (Figure 8-12):

Figure 8-11: Outlet from Wungong E Stages 3/4/5 to Vegetated Treatment Area in NBSMD Corridor, Example 1

Source: Photograph by the author

Figure 8-12: Outlet from Wungong E Stages 3/4/5 to Vegetated Treatment Area in NBSMD Corridor, Example 2

Source: Photograph by the author

Additionally, this infrastructure adds to the crowding in what is a cluttered public open space, as shown below in Figure 8-13. The design of the NBSMD corridor had to balance the objectives of a number of parties, including 'the City of Armadale and the Water

Corporation, the Department of Water, the MRA...that didn't align', according to interviewee Z. The addition of further infrastructure to this area does not add to its value as public open space.

Figure 8-13: NBSMD Corridor, Adjacent to Wungong E Stages 3/4/5

Source: Photograph by the author

In summary, SLUP did not influence urban design outcomes in the residential area of Wungong E Stages 3/4/5. SLUP did result in the installation of urban water infrastructure in the NBSMD corridor, but this was not a positive urban design outcome.

8.4.3 Conclusions from the Wungong E Stages 3/4/5 Case

The findings indicate that, at Wungong E Stages 3/4/5, SLUP strongly influenced the urban stormwater management component of WSUD practice. The stormwater system was designed to maintain predevelopment flows and volumes from the 1-year 1-hour ARI storm and to infiltrate stormwater flows as close to source as possible. These requirements are specified in the LWMS and UWMP documents.

The urban water cycle component was also influenced by SLUP, via the requirement to treat and infiltrate stormwater as close to source as possible, minimising the disruption to the pre-development stormwater infiltration process. The need to collect and treat potentially polluted groundwater was also recognised. However, although the LWMS and the UWMP state that measures should be taken to enhance water conservation, and minimise the use of potable water, corresponding practices were not implemented.

The urban water infrastructure component was influenced by SLUP. The stormwater management requirements led to the use of household soakwells, a leaky stormwater system and vegetated treatment areas in the NBSMD corridor. A combination of urban stormwater infrastructure at different physical scales was adopted. That said, the use of street-scale raingardens was not pursued.

The urban stormwater infrastructure required to comply with SLUP requirements did not influence the urban form of the subdivision. SLUP did identify urban water infrastructure to install in the NBSMD corridor, but this infrastructure did not enhance the functionality of this space.

The factors that enhanced, or inhibited, the ability of SLUP to influence WSUD practices at Wungong E Stages 3/4/5 are summarised in Table 8-16:

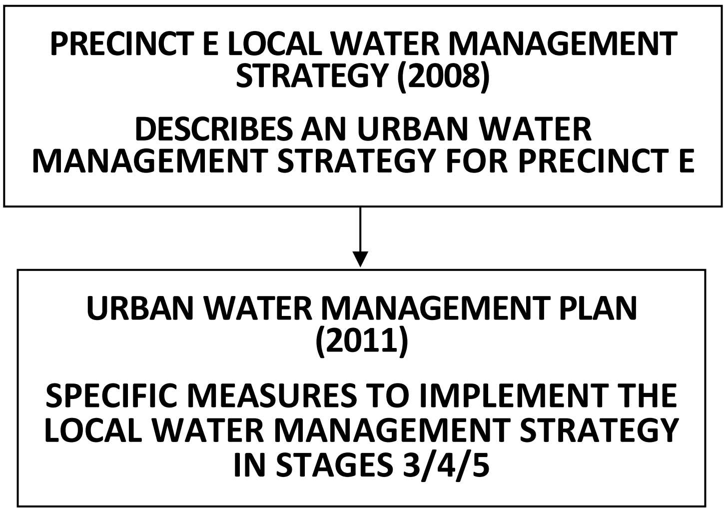
Table 8-16: Factors that Enhanced or Inhibited the Ability of Statutory Land Use Planning to Influence WSUD Practices at Wungong E Stages 3/4/5

Enhancing Factors	Inhibiting Factors
• Clear criteria for urban stormwater management • Requirement to infiltrate stormwater close to source • Flexibility to identify site-specific solutions to meet urban stormwater management requirements • Recognition of the urban water cycle early in the statutory land use planning process	• Lack of technical guidance and direction about how to comply with SLUP requirements • Use of street-scale raingardens was discouraged • Lack of a connection between statutory land use planning and large-scale urban water planning • Large number of agencies involved in the assessment and approval of SLUP tools

Source: original table

This table provides an understanding of individual factors related to the influence of SLUP on WSUD practices. As for Lane Gardens, the LWMS and the UWMP were the key SLUP tools that influenced WSUD practices at Wungong E Stages 3/4/5. This is shown schematically in Figure 8-14:

Figure 8-14: Process by which SLUP Influenced WSUD Practices at Wungong E Stages 3/4/5



Source: original figure

Figure 8-14 argues that the LWMS and UWMP strongly influenced WSUD practices at Wungong E Stages 3/4/5. These instruments directed that the predevelopment flows and volumes from the 1-year 1-hour ARI storm be maintained, and that stormwater flows be infiltrated as close to source as possible. These requirements were the key factor behind the adoption of a stormwater management regime including soakwells in housing lots, a leaky stormwater system and vegetated treatment areas in the NSBMD corridor.

SLUP also materially influenced the urban water cycle and urban water infrastructure components of WSUD practice. The stormwater controls help to maintain the natural urban water cycle, by infiltrating stormwater close to its source. Groundwater is collected and treated prior to discharge, which also protects the urban water cycle. The urban water infrastructure at Wungong E Stages 3/4/5 includes stormwater systems of varying physical scales, and so can be considered to incorporate both centralised and decentralised systems. However, street-scale raingardens were not supported by local government and were not installed.

The inclusion of household soakwells and a leaky stormwater system did not influence the design of the subdivision. The vegetated treatment areas in the NBSMD corridor, which treat and infiltrate stormwater runoff and groundwater collected by the subsoil drainage system, do not enhance its amenity.

At Wungong E Stages 3/4/5, SLUP did significantly influence the urban stormwater component of WSUD, while also providing some positive urban water cycle and urban water infrastructure outcomes. However, positive urban design outcomes were lacking.

8.5 Conclusions from the Western Australian Cases

In both Western Australian cases, the SLUP regimes included a LWMS (and the LWMS amendments, at Lane Gardens), which set out a broad urban water management strategy and an UWMP, which described how the strategy would be implemented, within the constraints applying to the site. Preparing these documents was consistent with *Better Urban Water Management* (Western Australia. Western Australian Planning Commission 2008a), issued by the state government to provide guidance about how State Planning Policy 2.9: Water Resources should be implemented. The LWMS amendments for Lane Gardens provided more specific direction about the technical measures that would be used, compared with the LWMS for Wungong E Stages 3/4/5. At Wungong E Stages 3/4/5, the application of SLUP tools such as the LWMS and UWMP was not yet mature. The contents of these tools, and their integration, were more clearly defined in the later Lane Gardens development.

In both cases, the influence of SLUP on WSUD practices was determined by the urban stormwater management requirements in the LWMS and UWMP tools. In response to these requirements, sets of stormwater management infrastructure, of varying physical scale, were installed at both sites. This approach also provided positive urban water cycle and urban water infrastructure outcomes.

However, there were some differences between the cases. Street-scale raingardens were adopted at Lane Gardens, but not at Wungong E Stages 3/4/5. More favourable urban design outcomes were also achieved at Lane Gardens. The findings suggest reasons for the different outcomes. Firstly, the Wungong Urban Water Project was a very early example of the *Better Urban Water Management* approach so that, as interviewee Y commented, ‘Wungong was the learning thing’. Thus, confidence in the WSUD philosophy and the accompanying technical guidance was still developing at the time of the Wungong E Stages 3/4/5 development. Secondly (and likely to be a consequence of the first), the local government was not supportive of the use of street-scale raingardens at Wungong E Stages 3/4/5, whereas, at Lane Gardens, the local government and the Department of Water supported a decentralised approach to urban stormwater management, and the inclusion of a rigorously planned living stream. Thirdly, there were physical differences between the sites, which influenced the ability to implement urban design outcomes. The living stream corridor at Lane Gardens provided a physical setting that could accommodate a range of uses, while allowing stormwater treatment infrastructure, such as the biofilter shown in Figure 8-4, to be included without prejudicing the amenity of the corridor. However, the NBSMD corridor adjacent to Wungong E Stages 3/4/5 is a regional drainage channel. The need to balance requirements such as drainage, community safety and recreation meant that the vegetated treatment areas at Wungong E Stages 3/4/5 had to be located in a physically constrained environment and did not enhance the amenity of the space.

An interesting aspect of the Wungong E Stages 3/4/5 case was the inclusion of a set of stormwater treatment targets. These quantitative stormwater targets were absent from the Lane Gardens case. However, the findings suggest that the targets did not influence WSUD practices.

Ultimately, while recognising that there are some differences between the two cases, they both demonstrate the ability of requirements to manage stormwater near its source to influence urban stormwater management, which also benefiting the other three components of WSUD practice. These requirements reduce the impact of urbanisation on the pre-development stormwater cycle, necessitate the use of stormwater systems at a range of scales and have the capacity to influence urban design outcomes.

This chapter described the findings of the Western Australian case studies. Chapter 9, which follows, uses the findings of these case studies, the findings of the Victorian case studies described in the previous chapter and the results of the survey reported in Chapter 5 to examine hypotheses about how SLUP influences WSUD practices.

Chapter 9

SYNTHESIS AND DISCUSSION OF THE RESULTS

9.1 Introduction

This Chapter integrates the findings of the survey and the case studies. Section 9.2 uses the findings of the survey and the case studies to re-examine the hypotheses identified in Chapter 5. Combining the findings of the survey and the case studies provides a more rigorous analysis than is possible using the findings of the survey alone. Using this analysis, Section 9.3 draws conclusions about how SLUP influences WSUD practices.

9.2 Hypotheses about the Influence of Statutory Land Use Planning on WSUD Practices

This section uses evidence from the survey and the case studies to examine the following hypotheses about how SLUP influences WSUD practices:

1. Hypothesis 1: SLUP materially encourages the adoption of WSUD practices in residential developments.
2. Hypothesis 2: SLUP tools that include specific quantitative targets encourage the adoption of WSUD practices in residential developments to a greater extent than tools that do not include specific quantitative targets.
3. Hypothesis 3: SLUP encourages the adoption of WSUD practices to a greater extent at greenfield residential developments, compared with infill residential developments
4. Hypothesis 4: SLUP encourages the implementation of the different components of WSUD practice identified in this research to different degrees, in residential developments

The following sub-sections individually examine each of these hypotheses.

9.2.1 Influence of Statutory Land Use Planning on the Adoption of WSUD Practices

To what extent does SLUP encourages the adoption of WSUD practices? In the survey, most quantitative and qualitative responses supported the view that SLUP encourages the adoption of WSUD practices. This encouragement was attributed to the legally binding nature of statutory planning requirements. The minority of respondents who rated the influence of SLUP as neutral or unfavourable did not suggest that SLUP lacks the potential to influence WSUD practices, but typically suggested that appropriate statutory requirements are not currently in place, or that supporting implementation measures are lacking. Generally, the survey supports the idea that SLUP encourages the implementation of WSUD practices.

The case studies provided additional, empirically derived evidence about this hypothesis. The interviewees were asked about the range of factors that influenced the adoption of WSUD practices, and the place of SLUP in that range. In the Coburg Hill case, an infill development in Victoria, there was strong consistency amongst the interviewees that WSUD practices would not have been implemented, in the absence of SLUP requirements related to urban stormwater treatment. Statutory planning was also identified as the most important factor that encouraged the adoption of WSUD practices. For the Davis Road case, a greenfield development in Victoria, most interviewees again suggested that SLUP strongly encouraged the adoption of WSUD practices. This encouragement was linked with urban stormwater treatment targets mandated by SLUP. In both the Coburg Hill and Davis Road East cases, WSUD practices were implemented to comply with mandatory SLUP requirements related to urban stormwater treatment.

In the Lane Gardens case study in Perth, according to the interviewees, SLUP was the foremost influence that encouraged the adoption of WSUD practices. The reported ability of SLUP to encourage WSUD practices was particularly associated with the requirements to prepare a LWMS, LWMS amendments and an UWMP. The UWMP was seen as particularly influential, as it had to be approved by the City of Gosnells, which was a strong advocate for WSUD and was reported to have clear ideas about the types of WSUD practices that should be installed at Lane Gardens, including a living stream. At the other Western Australian case study, Wungong E Stages 3/4/5, SLUP was also described as the key influence that led to the adoption of WSUD practices. As was the case for Lane Gardens, the LWMS and the UWMP were identified as important elements of the SLUP process. In both the Western Australian cases, the *Better Urban Water Management* framework (Western Australia. Western Australian Planning Commission

2008a), including the LWMS and UWMP documents, drove the adoption of the WSUD practices that were implemented.

Despite the overall case study findings that SLUP strongly encouraged the adoption of WSUD practices, a possible inhibiting mechanism was identified in the Davis Road East case study. What was described as a lengthy statutory planning process led to the developer's initial consideration of a decentralised approach to WSUD being discontinued, due to the possibility that the approval timeline could be further extended. This comment is consistent with previous findings that regulatory frameworks that are unduly complex and difficult to navigate can hinder the adoption of WSUD (Gardiner and Hardy 2005; Chandler and Eadie 2006), and that, in the urban water management context, statutory approvals 'tend to pause at anything that is new or unknown' (Shepherd 2014, 34). Although it would be unwise to place too much weight on a single example, this finding does suggest that statutory planning processes perceived as lengthy and complex may discourage innovative approaches to WSUD, which could face a more challenging approval pathway, compared with conventional WSUD practices.

While noting the previous paragraph, the findings of the survey and the case studies are consistent, and indicate that SLUP does materially encourage the adoption of WSUD practices. The mandatory legal force of SLUP is responsible for its ability to provide this encouragement. The evidence from the survey and the case studies demonstrates that, in the absence of appropriate SLUP requirements, the extent to which WSUD practices are adopted in Australian jurisdictions would be very much reduced. These findings, particularly the case studies, provide detailed empirical support for previous studies suggesting that the regulatory framework plays an important role in encouraging the adoption of WSUD practices in the Australian context (Campbell 1994; Wong and Eadie 2000; Lloyd 2001; Lloyd, Wong, and Chesterfield 2002; Taylor and Wong 2002a; Taylor and Wong 2002b; Taylor and Wong 2002c; Taylor and Weber 2004; Wong 2006a; Potter and RossRakesh 2007; Tjandraatmadja et al. 2014). The case studies also identified the specific statutory tools that led to WSUD practices being included in the developments. In summary then, the survey and case studies support the hypothesis that SLUP materially encourages the adoption of WSUD practices in residential developments.

These findings emphasise the importance, indeed the centrality, of SLUP in changing the behaviour of water sector participants. While not surprising in one sense, the findings point to the important regulatory influence of such planning rules in encouraging new practices and meeting public policy goals. The findings are consistent with, and reinforce, Freiberg's (2010) interpretation of statutory planning rules as a regulatory tool of government. However, we can go beyond just categorising statutory planning as a form of regulation. According to Grabosky's particularly useful comments, modern regulatory systems might best be viewed as 'layered webs of regulatory influence', of which conventional regulation by government is but one part (1995). While accepting Grabosky's view, the findings demonstrate clearly that statutory planning is a strong and effective web in its own right.

Having considered how SLUP influences WSUD practices, the next section will examine how specific quantitative targets mediate this influence.

9.2.2 Influence of Statutory Tools that Include Specific Quantitative Targets, Compared with Tools that do not Include Targets

The research examined the role that specific, quantitative targets play in encouraging the adoption of WSUD practices. While noting that a number of authors advocate the inclusion of specific, quantitative targets in the regulatory framework for WSUD (Taylor and Weber 2004; Kay et al. 2004; Chandler and Eadie 2006; Mouritz and Shepherd 2006; Potter and RossRakesh 2007; Corbett 2012, 2959; Tjandraatmadja et al. 2014, 81), Australian urban water resource management and land use planning professionals have expressed divided opinions about the merits of mandatory targets (Cooperative Research Centre for Water Sensitive Cities 2014a). While some supported such targets, others opposed them, suggesting that mandatory targets favour a narrow, 'tick the box' approach to WSUD practice and discourage innovation.

The results of the survey support the proposition that SLUP tools, which include specific quantitative targets, influence WSUD practices to a greater extent than tools lacking such targets. Logically, it can be inferred that SLUP tools that include specific quantitative targets are more effective at achieving public policy goals, compared with tools lacking targets. The participants attributed the greater influence associated with specific targets to the clear, unambiguous directions they provide. This clarity was contrasted with what was characterised as the lower levels of certainty provided by less-prescriptive controls.

The findings of the case studies were consistent with the survey on this matter. Thus, at Davis Road East in Victoria, the WSUD practices were specifically designed to meet quantitative stormwater treatment targets. In contrast, while statutory tools also required the use of more decentralised, street-scale WSUD measures to be considered, such measures were not adopted. At Coburg Hill in Victoria, stormwater treatment targets also determined the WSUD practices that were installed. While more decentralised stormwater infrastructure was used at Coburg Hill, compared with Davis Road East, this was a cost-effective solution to complying with the stormwater treatment targets at the high-land value Coburg Hill site. At Lane Gardens in Western Australia, a set of specific targets related to stormwater management (retain stormwater runoff generated by the 1-year 1-hour ARI storm close to the source; peak flows from the 1 year, 5 year and 100 year ARI storms should be attenuated to pre-development levels) were the determining factor in the stormwater management practices that were adopted. The inclusion of the living stream at Lane Gardens is of interest. Its installation was strongly advocated by the Department of Water and the City of Gosnells, during these agencies' assessment and approval of the LWMS amendments and the UWMP. While it was not installed to meet a specific quantitative requirement, its installation was effectively mandated, as a policy-based target. At Wungong E Stages 3/4/5 in Western Australia, specific targets for stormwater management (treat and infiltrate stormwater runoff generated by the 1-year 1-hour ARI storm, maintain discharge volumes and peak flow rates from the 1-year 1-hour ARI storm relative to pre-development levels) determined the stormwater management practices that were adopted. In contrast, general statements in the LWMS and the UWMP advocating water conservation did not lead to corresponding practices being adopted.

Taken together, the findings of the survey and the case studies support the hypothesis that SLUP controls, which include specific quantitative targets, more strongly encourage the adoption of WSUD practices, compared with controls that lack them. The findings provide empirical support for the suggestion that explicit targets are an important part of the regulatory framework for WSUD in meeting public policy goals.

While noting the capacity of specific targets to influence WSUD practices, there may be a risk that, where specific targets are used for some components of WSUD, but less prescriptive controls apply to other components, attention disproportionately focuses on the former. As an interviewee perceptively noted, in the context of the Davis Road East case, 'anything…that doesn't have an explicit target doesn't carry anywhere near the same weight' (interviewee L). These comments are consistent with the observation that, at Davis Road East, discretionary provisions that decentralised WSUD approaches should be 'considered' did not influence WSUD practices, in contrast to the strong influence of specific, mandatory stormwater treatment targets. Thus, while noting the evidence that specific targets do influence the adoption of WSUD practices, their potential to narrow the focus towards specific components of WSUD practice should not be disregarded.

9.2.3 Influence of Statutory Land Use Planning at Greenfield and Infill Sites

The results of the survey and the Victorian case studies allowed the extent to which SLUP influences WSUD practices at greenfield and infill residential developments to be examined. This analysis was previously described in section 7.5. Both the Western Australian case studies involved greenfield sites and therefore did not provide further information about this hypothesis, which will not be discussed further.

A key element of the research was the use of a novel analytical framework, including distinct components of WSUD practice. The influence of SLUP on these components is examined in the next section.

9.2.4 Influence of Statutory Land Use Planning on Components of WSUD Practice

This section examines how SLUP influences the components of WSUD practice identified in this research, according to the survey and the case studies. This allows the hypothesis that SLUP encourages the implementation of the components of WSUD practice to different degrees, in residential developments, to be examined.

Urban Stormwater Management Component

The evidence from the survey and the case studies consistently demonstrated that the adoption of stormwater management practices is strongly influenced by SLUP. Most participants in the survey rated the influence of SLUP on this component of WSUD practice as *encouraging* or *strongly encouraging*[140]. This influence was attributed to the inclusion of explicit, clear urban stormwater management requirements in SLUP.

Similarly, in the Coburg Hill case study in Victoria, all the rating-scale responses for this component were *encouraging* or *strongly encouraging*. The Coburg Hill interviewees attributed this influence to explicit, mandatory stormwater treatment targets. In response to these targets, a combination of stormwater treatment measures at different physical scales was installed at Coburg Hill. At Davis Road East, all the rating-scale responses for this component, with one exception, were *encouraging* or *strongly encouraging*, with this influence also associated with stormwater treatment targets. Compliance with these targets is achieved via end of line stormwater treatment systems. In both Victorian cases, explicit, mandatory stormwater treatment targets in the SLUP system dictated the stormwater management practices that were adopted.

At Lane Gardens in Western Australia, all the rating-scale responses for this component were *encouraging* or *strongly encouraging.* The interviewees linked this influence with explicit stormwater management targets, in response to which a decentralised set of stormwater infrastructure was installed. At Wungong E Stages 3/4/5, all the rating-scale responses for this component, with one exception, were *encouraging* or *strongly encouraging*, and this influence was associated with explicit stormwater treatment requirements. In both Western Australian cases, the stormwater management practices that were adopted were designed to comply with specific stormwater management targets, which were included in SLUP tools.

According to the qualitative and quantitative information from the survey and the case studies, SLUP does strongly encourage the adoption of stormwater management practices. The case studies directly linked stormwater targets with the urban

[140] The responses for the influence of statutory land use planning on the urban stormwater component were: 19 *strongly encouraging*; 19 *encouraging*; four *neither encouraging or discouraging*; three *discouraging*; one *strongly discouraging;* one *not sure.*

stormwater management measures included in the developments. It is noteworthy that the stormwater management requirements identified in the case studies differ between Western Australia and Victoria. The significance of this difference is examined in Chapter 10, which follows.

Urban Water Cycle Component

According to the survey responses, the influence of SLUP on the urban water cycle component is only slightly encouraging[141]. These results indicate a lesser degree of encouragement, compared with the urban stormwater component. The survey participants associated the less encouraging ratings for the urban water cycle component with a comparative absence of SLUP requirements related to the broader urban water cycle. However, divergent results for this component were obtained from the Western Australian cases studies, compared with the Victorian cases. Therefore, the case-study findings for each jurisdiction will be discussed separately.

The finding of the two Victorian case studies were consistent with the survey. At Coburg Hill, the rating-scale responses for this component included four *neither encouraging or discouraging* responses and a total of three *strongly encouraging* and *encouraging responses*. Urban water cycle management was addressed at Coburg Hill by the installation of rainwater tanks, which collect roof runoff and reuse this water for domestic purposes. However, the interviews found that the rainwater tanks were primarily installed to reduce the volume of stormwater that requires treatment, in order to comply with the stormwater targets. At Davis Road East, the rating-scale responses were the same as for Coburg Hill. The only specific practice intended to address the broader water cycle included in the SLUP regime at Davis Road East supported the use of recycled water. However, this is merely implementing what is largely accepted practice in greenfield developments in Melbourne (Lazarova et al. 2013, 142-143). In both Victorian cases, the focus of SLUP was urban stormwater management, rather than the broader urban water cycle.

[141] The responses for the influence of statutory land use planning on the urban water cycle component were: two *strongly encouraging*; 17 *encouraging*; 15 *neither encouraging or discouraging*; 10 *discouraging*; *two strongly discouraging;* one *not sure.*

The Lane Gardens case study in Western Australia contrasted with the Victorian cases. The rating-scale responses (one *neither encouraging or discouraging* and at total of five *encouraging and strongly encouraging* responses) indicated that SLUP did encourage the adoption of practices related to the urban water cycle at this site. These ratings were consistent with the observation that statutory planning tools for this development do consider the urban water cycle, and specify measures such as localised capture and infiltration of stormwater, water efficient landscaping, using groundwater for public open space irrigation and treatment of potentially polluted groundwater. There was also some attention to the broader urban water cycle at Wungong E Stages 3/4/5 (rating-scale responses: three *neither encouraging or discouraging*, two *encouraging*), in that the development provides for localised capture and infiltration of stormwater, and capture and treatment of potentially polluted groundwater, before it is discharged from the site. However, specific water conservation practices were not adopted, despite the LWMS and the UWMP including water conservation as an objective. Thus, in both the Western Australian cases, the urban water cycle was considered, to an extent.

In summary then, the findings of the survey and the Victorian case studies consistently indicate that SLUP does little to encourage the adoption of WSUD practices related to the urban water cycle. However, in both Western Australian cases, SLUP did help to maintain the pre-development urban water cycle, by requiring localised infiltration of stormwater, and explicitly considering groundwater management.

Urban Water Infrastructure Component

The ratings from the survey suggest that the influence of SLUP on the urban water infrastructure component is not significant[142] indicating that, in the eyes of the participants, SLUP does little to foster the use of a combination of centralised and decentralised urban water systems.

Turning to the case studies, at Coburg Hill in Victoria, the ratings for this component (four *neither encouraging or discouraging* and a total of three *strongly encouraging* and *encouraging*), suggest a degree of encouragement, consistent with the combination of

[142] The responses for the influence of statutory land use planning on the urban water infrastructure component were: two *strongly encouraging*; eight *encouraging*; 23 *neither encouraging or discouraging*; 10 *discouraging*; one *not sure.*

centralised and decentralised urban water systems at this site. The interviews found that this combination was a cost-effective way to comply with the stormwater treatment targets at a high land-value site. At the other Victorian case study, Davis Road East, the rating-scale responses (two *Neither encouraging or discouraging*, four *encouraging*, one *strongly encouraging*) suggest that SLUP did, to a degree, encourage the use of a combination of centralised and decentralised urban water infrastructure. Reconciling these ratings with the reliance on end of line stormwater systems at this site requires some explanation. The interviews found that the treatment systems were designed to meet stormwater treatment targets, but SLUP provided no guidance about whether the resulting treatment systems can be deemed to be comparatively 'centralised' or 'decentralised'. In both the Victoria cases, the design of the stormwater treatment infrastructure was determined by the stormwater treatment targets, which do not provide guidance about the physical scale at which treatment systems should be installed.

In the Lane Gardens case in Western Australia, the rating-scale responses (one *neither encouraging or discouraging*, four *encouraging*, one *strongly encouraging*) suggest a degree of encouragement, which is consistent with the use of urban stormwater infrastructure at a range of scales, at this site. This approach was designed to meet SLUP requirements that stormwater be collected and infiltrated close to its source. Similarly, at Wungong E Stages 3/4/5, (rating-scale responses: one *discouraging*, one *neither encouraging or discouraging*, three *encouraging*) the SLUP requirement for stormwater to be managed close to its source resulted in infrastructure at a range of physical scales being installed. In both the Western Australian cases, the requirement for stormwater to be managed close to source resulted in the installation of stormwater infrastructure at a range of scales. Thus, in these cases, SLUP did encourage the adoption of a portfolio of centralised and decentralised infrastructure.

The findings of the survey and the Victorian cases are consistent, and suggest that the influence of SLUP on the infrastructure component of WSUD practice is not significant. However, in the Western Australian cases, the influence of SLUP on this component was encouraging, due to the condition that stormwater be managed close to source.

Urban Design Component

The ratings in the survey suggest that SLUP has some influence on the urban design component, but that this influence is less encouraging, compared with the urban stormwater component [143]. The comments in the survey indicate that SLUP does little to link management of the urban water cycle and urban design processes.

At Coburg Hill, the rating-scale responses for this component included four *encouraging* responses and three *neither encouraging or discouraging* responses*,* pointing to some degree of encouragement, which is consistent with the use of the statutory planning system to integrate harmoniously infrastructure, such as rainwater tanks and raingardens located in road reserves, with the urban fabric. However, the integration of these elements took place at a localised scale. More fundamentally, the urban form of Coburg Hill was determined by a range of planning considerations other than urban water management, and urban water infrastructure was accommodated within the resulting design, 'so WSUD wasn't the driver of the urban design outcomes', according to interview G. At Davis Road East, the rating-scale results were divergent (three *strongly encouraging* responses and four *neither encouraging or discouraging* responses). Nonetheless, the case study findings indicate that, at this development, SLUP resulted in the installation of end of line stormwater treatment systems in a waterway corridor, with marginal influence on the urban form of the development. In both Victorian cases, the influence of SLUP on urban design outcomes was limited.

In the Lane Gardens case, the rating-scale responses (two *strongly encouraging*, three *encouraging* and one *neither encouraging or discouraging*) suggest that SLUP did influence this component. These ratings were consistent with the findings that measures to manage the urban water cycle, such as roadside raingardens, biofilters and a living stream were integrated with the development and had materially influenced the development's urban form. At Wungong E Stages 3/4/5 (rating-scale responses: one *discouraging*, one *neither encouraging or discouraging*, one *encouraging*, two *strongly encouraging*), SLUP was a key factor in establishing the open space corridors that border

[143] The responses for the influence of statutory land use planning on the urban design component were: six *strongly encouraging*; 14 *encouraging*; 20 *neither encouraging or discouraging*; five *discouraging*; one *strongly discouraging;* one *not sure.*

the site and provide, among other uses, stormwater management functions. However, the urban form at the street scale was not significantly influenced by SLUP and the introduction of urban water infrastructure in the NBSMD corridor did not enhance its amenity. In both Western Australian cases, SLUP required documents to be prepared (LWMS and UWMP), to align land use and urban water management planning.

According to the survey and the Victorian case studies, SLUP generally does not result in urban water management strongly influencing urban design outcomes. However, Lane Gardens did provide an example where SLUP established a nexus between urban water cycle planning and urban design, producing favourable urban design outcomes. At Wungong E, stages 3, 4 and 5, SLUP directly influenced the large-scale setting for the development, but did not materially influence urban form at the street scale.

Having considered the research findings about how SLUP influences each of the components of WSUD practice, the following sub-section compares the influence on the urban stormwater component with the influence on the other three components.

Comparison of the Influence of SLUP on Urban Stormwater Management with the Influence of SLUP on other Components of WSUD Practice

On balance, the findings of the survey and case studies support the hypothesis that SLUP encourages the implementation of the different components of WSUD practice identified in this research to different degrees, in residential developments. The quantitative and qualitative evidence from the survey both indicate that SLUP provides more encouragement for the adoption of urban stormwater management practices, compared with the other three components. The findings of the two Victorian case studies are also consistent with this conclusion.

The two Western Australian cases require a more nuanced interpretation. SLUP did materially influence all the components of WSUD practice at Lane Gardens, although some interviewees identified stronger, more explicit references to the urban stormwater component in the SLUP regime, compared with the other components. At Wungong E Stages 3/4/5, SLUP also influenced all the components of WSUD practice, although here urban design outcomes related mainly to the identification of multiple-use open space corridors bounding the site, rather than at the street scale. In both Western Australian cases, *Better Urban Water Management* (Western Australia. Western Australian Planning Commission 2008a) provided a framework to link urban design and urban water management planning processes.

The research findings indicate that, in residential developments, Australian SLUP systems more strongly encourage the adoption of WSUD practices related to the urban stormwater component, compared with the other components. This difference is associated with the inclusion of explicit, mandatory targets related to urban stormwater management, which contrasts with a comparative absence of requirements related to the other three components. Urban stormwater targets can be expressed in quantitative terms, removing the potential for varying interpretations and allowing compliance to be assessed by technical procedures. In contrast, discretionary provisions related to other components of WSUD practice, such as those requiring decentralised, street-scale WSUD measures to be considered at Davis Road East, and encouraging water conservation practices at Wungong E Stages 3/4/5, have little influence.

9.3 Conclusions

The findings of the survey and the case studies allowed a number of hypotheses related to the influence of SLUP on the implementation of WSUD practices to be tested. The findings support the hypothesis that SLUP does materially encourage the adoption of WSUD practices. This influence was attributed to SLUP including legally binding requirements related to WSUD. The evidence also supports the proposition that statutory tools that include explicit, quantitative targets more strongly encourage WSUD practices, compared with tools which lack such targets. The two Victorian cases suggest that, at least in the Victorian context, Wong and Eade's view (2000) that statutory planning has greater capacity to encourage WSUD practices at greenfield sites, compared with infill sites, should be qualified, to recognise that SLUP may be just as influential at infill developments, as long as they are sufficiently large to allow statutory planning controls to be applied to them. The findings suggest that SLUP more strongly encourages the adoption of WSUD practices related to the urban stormwater component, compared with the other components, although this difference was less clear cut in the Western Australian cases.

The findings about the influence of SLUP on the components of WSUD practice can be considered in the context of the varying interpretations of WSUD discussed in this thesis. It was noted in Chapter 2 that a broad vision of WSUD, extending beyond urban stormwater management, to encompass the complete urban water cycle, and linking urban water management and urban design, is advocated by authors such as Wong (2006a; 2006b), and Wong and Ashley (2006). According to Hoyer (2011), it is WSUD's explicit, strong link between urban water management and urban design that distinguishes it from other urban water concepts. However, the findings of the survey and the two Victorian cases indicate that, to a significant extent, current Australian SLUP systems focus on urban stormwater management and do not adequately recognise the broader aspects of the WSUD concept. This weakens the ability to differentiate WSUD, as it is practised in Australia, from other urban water management models.

This chapter examined individual hypotheses about the influence of SLUP on WSUD practices, and also considered how SLUP influences components of WSUD practice. It could thus be described as having a reductionist perspective. Further insights can be gained be considering SLUP systems in a more holistic sense. The next chapter compares the findings of the case studies at a broad level, identifying differences between the Victorian and Western Australian SLUP systems. Potential reasons for these differences are examined. Ways to enhance the ability of SLUP to encourage the adoption of WSUD practices are also considered, based on the findings of the research.

Chapter 10

CASE STUDIES FINDINGS AND THEIR IMPLICATIONS

10.1 Introduction

The Chapter will examine the findings of the Victorian and Western Australian cases, in order to compare how the Victorian and Western Australian SLUP systems influence WSUD practices. This comparison provides insights into how to design SLUP frameworks, to enhance their ability to promote WSUD.

Section 10.2 provides a high-level summary of the findings of each case study and an overall summary of the findings. Section 10.3 draws on these findings to compare the Victorian and Western Australian SLUP systems. It also provides an explanation for the different characteristics of these systems. Section 10.4 shows how SLUP, in effect, interprets the WSUD concept and, in turn, influences that concept. It shows that this process can, of itself, hinder the adoption of a broad interpretation of WSUD, which includes the urban water cycle as a whole, and the interaction of this cycle with urban design. Section 10.5 compares the findings of the research with previous investigations of the implementation of WSUD in Australia. Section 10.6 draws on the research findings to identify how SLUP systems should be designed, to enhance their capacity to promote WSUD practices. Connections between the research in this thesis and other current research about WSUD are considered in section 10.7. Key findings are summarised in section 10.8.

10.2 Summary of the Case Study Findings

To facilitate comparison of the case studies, the following tables summarise their key findings. A separate table is provided for each case study. The tables show, for each of the four components of WSUD practice identified in the thesis, the WSUD practices included in the development and the relevant SLUP requirements. The tables provide a succinct overview of each case study.

Victorian Case Studies

Table 10.1 summarises the findings of the Coburg Hill case study:

Table 10-1: Summary of Findings of the Coburg Hill Case Study, Victoria

Component of WSUD Practice	Practices Related to this Component Included in the Development	Key SLUP Requirements Related to the Component of WSUD Practice
Urban stormwater management	Stormwater is treated by street-scale raingardens, a biofiltration strip installed in the entrance boulevard and two end of line systems. Rainwater tanks collect runoff from dwelling roofs.	Stormwater treatment requirements in the BPEMG referenced by Clause 56.07 of the Moreland Planning Scheme.
Urban water cycle	Rainwater from dwelling roofs is collected in rainwater tanks and reused, reducing the volume of potable water supplied to the development from the centralised system.	Stormwater treatment requirements in the BPEMG: rainwater tanks reduce the volume of stormwater requiring treatment at a constrained inner city development site, with high land value.
Urban water infrastructure	Stormwater is managed via infrastructure at a range of physical scales (household, street-scale and end of line).	Stormwater treatment requirements in the BPEMG: managing stormwater at the household and street-scales reduces the land required for end of line treatment, maximising the land that can be developed and sold for housing.
Urban design	The design of urban water infrastructure such as rainwater tanks, street-scale raingardens and end of line stormwater treatment systems is integrated with the urban form, which enhances local amenity.	The overall urban form of the development was determined by planning considerations other than urban water cycle management. At the local scale, integration of urban water infrastructure such as street-scale raingardens and rainwater tanks with urban form was considered in permit applications for individual stages of Coburg Hill.

Source: original table

At Coburg Hill, SLUP strongly influenced the urban stormwater management component, via the treatment targets in the BPEMG. A combination of the stormwater treatment requirements and the high land value at Coburg Hill led to the adoption of a stormwater system that includes centralised and decentralised measures.

There were some positive outcomes related to the urban water cycle, urban water infrastructure and urban design components of WSUD practice, but these were incidental results associated with the need to comply with the stormwater treatment requirements.

Table 10.2 summarises the findings of the Davis Road East case study:

Table 10-2: Summary of Findings of the Davis Road East Case Study, Victoria

Component of WSUD Practice	Practices Related to this Component Included in the Development	Key SLUP Requirements Related to the Component of WSUD Practice
Urban stormwater management	Stormwater is treated in four end of line systems, which are located in a waterway reserve adjoining the residential development.	Stormwater treatment requirements in the BPEMG referenced by Clause 56.07 of the Wyndham Planning Scheme.
Urban water cycle	Buildings in the development have the capacity to use recycled water.	Planning permit conditions that the development allows recycled water to be used.
Urban water infrastructure	End of line stormwater treatment systems only. No street-scale urban water infrastructure.	Riverdale Precinct Structure Plan and the planning permit required localised, street-scale WSUD measures to be 'considered'. However, such measures were not adopted.
Urban design	The stormwater treatment systems are located in a waterway corridor. There is little evidence that the urban form of the development was influenced by the urban water cycle.	Localised, street-scale WSUD measures were to be 'considered'. Such measures were not adopted, so the potential for such measures to influence urban design outcomes was not realised.

Source: original table

At Davis Road East, SLUP strongly influenced the urban stormwater management component, via the treatment targets in the BPEMG. SLUP mandated the use of recycled water and influenced the urban water cycle component, to the extent that it included this requirement.

SLUP required localised, street-scale WSUD measures to be 'considered', but such measures were not adopted, so positive urban water infrastructure and urban design outcomes associated with decentralised, street-scale WSUD systems were not achieved.

Western Australian Case Studies

The findings of the Lane Gardens case study are summarised in Table 10-3:

Table 10-3: Summary of Findings of the Lane Gardens Case Study, Western Australia

Component of WSUD Practice	Practices Related to this Component Included in the Development	Key SLUP Requirements Related to the Component of WSUD Practice
Urban stormwater management	Stormwater is treated by a system that includes measures at a range of physical scales. The system includes household soakwells, raingardens in road reserves and biofilters in public open space. Runoff from storms exceeding the 1-year 1-hour ARI event is discharged to a living stream.	SLUP tools (the 2005 LWMS, the 2014 LWMS amendments and the UWMP) require stormwater to be managed to: 1. Retain and infiltrate the runoff generated by the 1-year 1-hour ARI storm as close to source as possible 2. Maintain pre-development peak stormwater flow rates and volumes for the 1 year, 5 year and 100 year ARI storm events.

Urban water cycle	Runoff from storms, that do not exceed the 1-year 1-hour ARI storm, is infiltrated as close to source as possible. Potable water consumption is reduced by landscaping and planting designed to reduce water demand, and the use of groundwater for public open space irrigation. Subsurface drains are lined with a medium that treats groundwater to remove pollutants, before it is discharged from the site.	SLUP requires stormwater from the 1-year 1-hour ARI storm to be infiltrated as close to source as possible, and pre-development flow rates and volumes to be maintained. SLUP tools (2014 LWMS amendments and the UWMP) identify measures to reduce potable water consumption. SLUP tools (2014 LWMS amendments and the UWMP) require lining of the subsurface drains, to prevent polluted groundwater being discharged from the site.
Urban water infrastructure	A combination of infrastructure, of various physical scales, is used to manage urban stormwater.	SLUP tools require stormwater from the 1-year 1-hour ARI storm to be collected and infiltrated as close to source as possible, and pre-development flow rates and volumes to be maintained. A combination of urban water infrastructure, at a range of physical scales, is used to comply with this condition.
Urban design	Urban form is influenced by WSUD elements, such as roadside raingardens, biofilters in public open space and a living stream. The living stream provides a particularly strong urban design element.	SLUP tools require stormwater from the 1-year 1-hour ARI storm to be collected and infiltrated as close to source as possible, and pre-development flow rates and volumes to be maintained. A combination of urban water infrastructure, at a range of physical scales, is used to comply with this condition. This infrastructure influences urban form. The 2005 LWMS, the 2014 LWMS amendments and the UWMP aligned the design of urban form and urban water cycle management at key steps in the land development process. The 2014 LWMS amendments and the UWMP mandated the inclusion of the living stream in the development.

Source: original table

At Lane Gardens, all four components of WSUD practice were materially encouraged by SLUP. The stormwater management regime mandated by SLUP influenced the urban stormwater management, urban water cycle and urban water infrastructure components. The urban form of the development was significantly influenced by the urban water cycle.

Importantly, SLUP planning tools (the 2005 LWMS, the 2014 LWMS amendments and the UWMP) ensured that urban water planning was considered at key stages in the land use planning process.

The findings of the Wungong E Stages 3/4/5 case study in Western Australia are summarised in Table 10-4:

Table 10-4: Summary of Findings of the Wungong E Stages 3/4/5 Case Study, Western Australia

Component of WSUD Practice	Practices Related to this Component Included in the Development	Key SLUP Requirements Related to the Component of WSUD Practice
Urban stormwater management	Stormwater is treated by a system that includes measures at a range of physical scales. The system includes household soakwells, a 'leaky' stormwater system and vegetated treatment areas in a public open space corridor. Runoff from storms exceeding the 1-year 1-hour ARI event is discharged to multiple use public open space corridors, that combine stormwater conveyance with recreational use in landscaped settings.	SLUP tools (the LWMS and the UWMP) required stormwater to be managed to: 1. Retain and infiltrate the runoff generated by the 1-year 1-hour ARI storm as close to source as possible 2. Maintain pre-development peak stormwater flow rates and volumes for the 1-year 1-hour ARI storm event.
Urban water cycle	Stormwater runoff from the 1-year 1-hour ARI storm is infiltrated as close to source as possible. Groundwater is collected and treated prior to discharge.	SLUP requires stormwater from the 1-year 1-hour ARI storm to be infiltrated as close to source as possible, and pre-development flow rates and volumes for this storm to be maintained. The UWMP requires groundwater treatment.
Urban water infrastructure	A combination of infrastructure, of various physical scales, is used to manage urban stormwater.	As indicated above, SLUP tools require stormwater from the 1-year 1-hour ARI storm to be collected and infiltrated as close to source as possible, and pre-development flow rates and volumes for this storm to be maintained. A combination of urban water infrastructure, at a range of physical scales, is used to comply with this condition
Urban design	The development is integrated with multiple-use public open space corridors, which combine stormwater treatment and conveyance with recreational use, in landscaped settings. Vegetated treatment areas, which treat and infiltrate stormwater runoff and groundwater from the development, are installed in the NBSMD corridor. These areas do not enhance amenity.	The Wungong Urban Water Redevelopment Scheme Master Plan and the Precinct E Structure Plan identify public open space corridors that adjoin the development, which provide multiple uses, including stormwater treatment and conveyance. SLUP tools require stormwater from the 1-year 1-hour ARI storm to be collected and infiltrated as close to source as possible, and pre-development flow rates and volumes for this storm to be maintained: the treatment system used to comply with this condition includes vegetated treatment areas in the NBSMD corridor. The LWMS and UWMP aligned the design of urban form and urban water cycle management at key steps in the land development process.

Source: original table

At Wungong E Stages 3/4/5, the stormwater management regime mandated by SLUP influenced the urban stormwater management, urban water cycle and urban water infrastructure components.

The residential area is integrated with adjoining public open space corridors that provide multiple uses, including stormwater treatment and conveyance. Combined stormwater and groundwater outlets that discharge to vegetated treatment areas are located in the NBSMD corridor, but these installations do not enhance amenity.

SLUP planning tools (the LWMS and UWMP) ensured that urban water planning was considered at key stages in the land use planning process.

Comparison of the Case Studies

Having examined each case study, the information in Tables 10-1 to 10-4 above can be further summarised, so assist comparison of the cases. Table 10-5, following, provides this summary:

Table 10-5: Summary of the Case-Study Findings

Case Study	Influence of SLUP on Components of WSUD Practice:			
	Urban Stormwater Management	**Urban Water Cycle**	**Urban Water Infrastructure**	**Urban Design**
Coburg Hill, Victoria	Stormwater is treated to comply with the pollutant removal requirements in the BPEMG.	Rainwater tanks are used to collect and reuse roof runoff, to reduce the volume of stormwater requiring treatment.	A combination of stormwater treatment devices, of varying scales, is used to minimise the area of land set aside for stormwater treatment.	At the local scale, urban water infrastructure is integrated with the development. At a wider scale, urban form was dictated by influences other than the urban water cycle.
Davis Road East, Victoria	Stormwater is treated to comply with the pollutant removal requirements in the BPEMG	Buildings in the development have the capacity to use recycled water.	Stormwater is treated via four sub-catchment scale systems.	The stormwater treatment systems are located in a waterway corridor. Little evidence that the urban form of the development was influenced by the urban water cycle.
Lane Gardens, Western Australia	Stormwater from the 1-year 1-hour ARI storm is treated and infiltrated close to source. Stormwater from the 1-year 1-hour ARI storm, and larger storms, is managed to maintain pre-development flows.	Infiltration of stormwater helps to maintain the pre-development water cycle. Some measures are used to reduce potable water consumption. Groundwater discharges are treated to remove pollutants.	A combination of infrastructure, at varying scales (household, street-level, public open space), is used to manage stormwater runoff.	Urban form is influenced by the roadside raingardens, biofilters in public open space and the inclusion of a living stream.
Wungong E Stages 3/4/5, Western Australia	Stormwater from the 1-year 1-hour ARI storm is treated and infiltrated close to source. Stormwater from the 1-year 1-hour ARI storm is managed to maintain pre-development flows.	Infiltration of stormwater helps to maintain the pre-development water cycle. Groundwater discharges are treated to remove pollutants	A combination of infrastructure, at varying scales (household, street-level, public open space), is used to manage stormwater runoff.	The development is integrated with multiple-use public open space corridors. Vegetated treatment areas, which treat stormwater and groundwater are installed in the NBSMD corridor. Elements at the street scale, such as road layout, were not influenced by the urban water cycle.

Source: original table

Table 10.5 indicates that there are notable differences in the extent to which the components of WSUD practice were adopted in the case studies. Generally, the adoption of WSUD practices across the four dimensions of WSUD practice identified in this thesis is more comprehensive in the Western Australian case studies, compared with the Victorian examples.

The following section considers possible links between the SLUP regimes that applied to the case studies and these varying WSUD outcomes.

10.3 Comparison Between the Victorian and Western Australian SLUP Systems

This section uses the findings of the case studies to compare the Victorian and Western Australian SLUP systems. As well as identifying differences between these systems, it also explains the origin of these differences.

10.3.1 Comparison of Victorian and Western Australian Case Study Findings

The case studies identified differences in the extent to which WSUD practices were adopted. Considering the three greenfield cases, that is, Davis Road East in Victoria, and Lane Gardens and Wungong E Stages 3/4/5 in Western Australia, the implementation of WSUD practices is more extensive in the Western Australian examples.

In all cases, the SLUP regime included explicit stormwater management conditions. According to the analysis in the previous chapter, specific, quantitative targets strongly influence WSUD practices. This suggests that, in seeking to understand possible reasons for the differences between the findings of the Victorian and Western Australian cases, an examination of the influence of stormwater targets on WSUD practices in these jurisdictions is warranted.

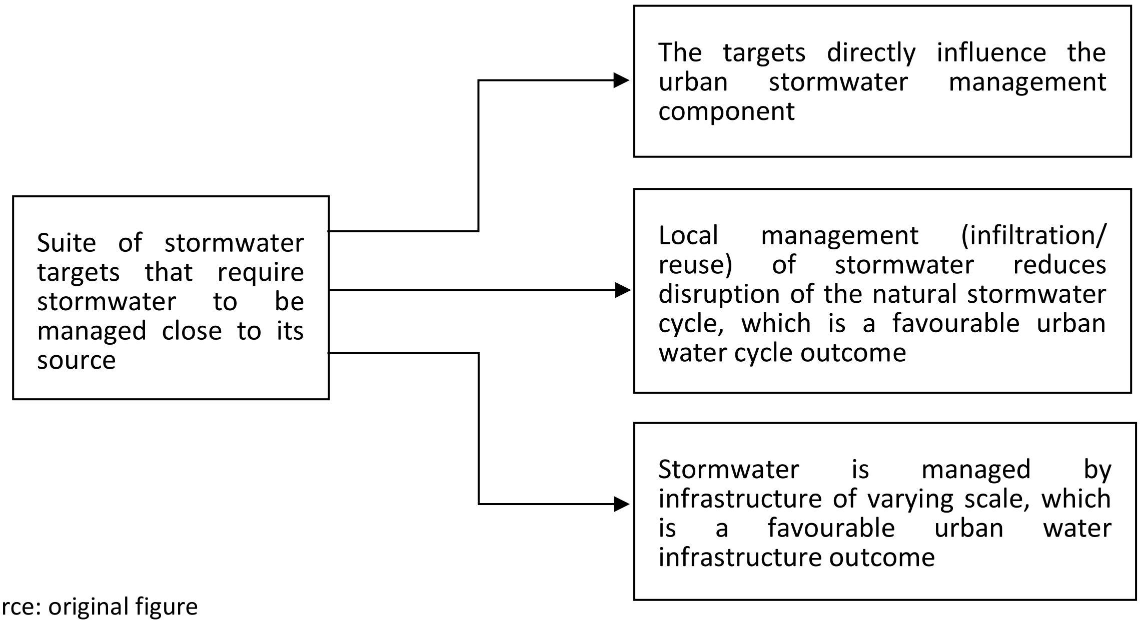
In Western Australia, a suite of stormwater targets applied in both cases, requiring runoff from the 1-year 1-hour ARI storm to be infiltrated as close to source as possible, and maintenance of pre-development stormwater flows and volumes. In the case studies, these requirements strongly influenced the urban stormwater component. Turning to the urban water cycle component, infiltration close to source helps to reduce the extent to which urban development disturbs the stormwater element of the urban water cycle. Infiltrating stormwater close to its source is achieved by infrastructure at varying physical scales, which is consistent with the desired use of a combination of centralised and decentralised systems identified by the urban water infrastructure component. The overlapping, favourable outcomes for the urban stormwater, urban water cycle and urban water infrastructure components can be attributed to the explicit reference to physical scale in the suite of stormwater requirements. While the term 'as close to source as possible' does not establish an absolute scale, it does convey a clear message about the desire to avoid sole reliance on end of line urban stormwater infrastructure.

In the Victorian case studies, the key stormwater requirement was compliance with the treatment targets in the BPEMG. This requirement directly addresses the stormwater component of WSUD practice. However, in the absence of explicit references to scale, the Victorian stormwater targets did not necessarily result in the adoption of infrastructure at a range of physical scales, designed to manage stormwater near its source. In the Davis Road East case study, the lack of clarity about physical scale was noted during the interviews. While the BPEMG targets did lead to a combination of centralised and decentralised infrastructure at Coburg Hill, this approach was a financially driven response to the specific circumstances at that location. The Victorian stormwater targets do not inherently consider scale, which means they do not necessarily encourage the adoption of stormwater infrastructure at a range of physical scales, with the associated favourable urban water cycle and urban water infrastructure outcomes.

10.3.2 The Importance of Physical Scale

The evidence from the case studies suggests that the ability of stormwater targets to encourage the adoption of decentralised WSUD practices, which also foster the urban water cycle and urban water infrastructure components of WSUD practice, is increased by including a physical scale, which requires stormwater to be managed close to its source. We might present this observation schematically, as shown in Figure 10-1:

Figure 10-1: Influence of Stormwater Targets that Include Physical Scale on Components of WSUD Practice



Source: original figure

The case studies also provide insights into how SLUP influences the urban design component, at the subdivision scale. The greatest influence of SLUP on urban design outcomes was at Lane Gardens. At this development, stormwater management is effected by a range of measures, including raingardens in road reserves, biofilters in public open space and the living stream, which materially influenced its form. The location of these measures within the development, and their physical extent, meant that urban form had to respond to them, to a material extent. At the other Western Australian case, Wungong E Stages 3/4/5, the stormwater management system included vegetated treatment areas installed in the NBSMD corridor that adjoins the development. However, within the development, urban form was not influenced by urban water cycle management. At Coburg Hill in Victoria, the stormwater targets in the BPEMG are achieved by a combination of measures that include rainwater tanks, street-scale raingardens and a biofiltration swale in the entrance boulevard. The influence of these measures on urban form is limited to minor changes to accommodate the urban water infrastructure, with the overall urban form being determined by factors other than urban water management. In the Davis Road East case, BPEMG targets are met by end of line stormwater treatment systems accommodated within a waterway corridor, which had little influence on the overall urban form of the development. In each case study, the extent to which SLUP influences urban design outcomes is determined by the treatment measures used to comply with the stormwater management requirements and how these are integrated with urban form.

The case studies suggest that, for SLUP to materially influence urban design outcomes within a subdivision:

1. Complying with SLUP must require the installation of decentralised urban water infrastructure.
2. The urban water infrastructure installed at the local scale must be large enough to influence urban form.

In summary, the underlying cause of the varied adoption of the components of WSUD practice in the case studies can be identified as the urban stormwater requirements that applied to each case. Looking beyond the urban stormwater component, the influence of these requirements on the urban water cycle, urban water infrastructure and urban design components of WSUD practice is increased when they include a physical scale, directing that stormwater be managed close to its source.

10.3.3 Explanation for the Differences Between the Victorian and Western Australian SLUP Systems

An understanding of the potential causes of the differing characteristics of the SLUP systems in Victoria and Western Australia is provided by Brown and Clarke's (2007) multi-level framework, which they use to analyse the adoption of urban stormwater quality management (USQM) practices in Melbourne. The USQM practices considered by Brown and Clarke include the stormwater treatment targets in the BPEMG. Their framework, as discussed previously in section 3.3.4, includes the following levels:

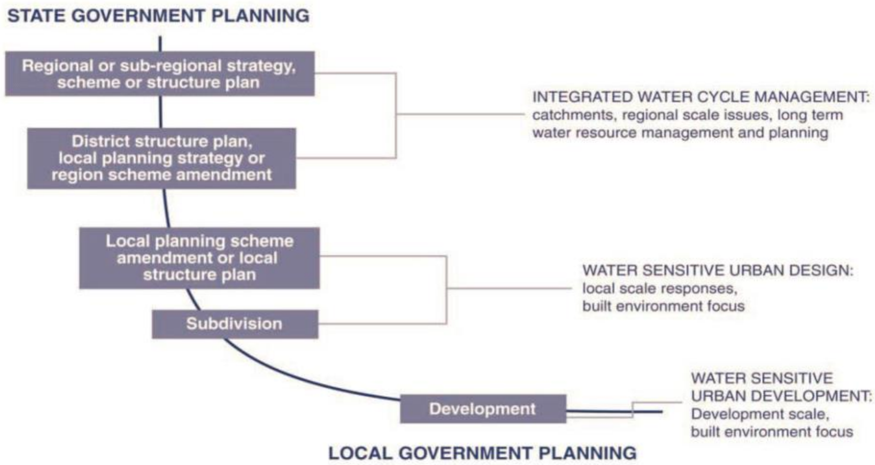
1. Macro-level: socio-political and bio-physical systems
2. Meso level: institutional level, including water industry, regulators, government policy makers
3. Micro level: technical and product development level.

According to Brown and Clarke, a complex set of interactions between the three levels over a period of several decades, commencing in the 1960s, led to USQM, including the stormwater targets in the BPEMG, becoming mainstream practice in the first decade of the current century. Many of the factors that Brown and Clarke identify as critical to the mainstream acceptance of USQM (2007, v), including the BPEMG targets, were specific to Melbourne. These include, for example, threats to the health of Port Phillip Bay (a critical recreational and environmental asset for Melbourne) associated with pollutants in stormwater runoff, the prevailing organisational architecture and the network of champions advocating change.

If Brown and Clarke's transition theory approach is accepted, it follows that the different conditions in Western Australia, interacting at the macro, meso and micro levels, would be likely to result in the Western Australian SLUP system including different controls related to WSUD practices, compared to Victoria. An example of the contrasting circumstances in Western Australia and Victoria is the different soil types in their capitals, Perth and Melbourne, respectively, which have significant implications for WSUD practice. Perth soils are predominantly comprised of sands (Sharma et al. 1996, 107; Argue et al. 2004, 154), whereas extensive parts of the Melbourne metropolitan area are located in soils with high levels of low-permeability clay (Williams, McDonnell, and Seager 2005, 37; Victoria. Department of Agriculture 2015). These different physical conditions strongly affect the ability to infiltrate stormwater close to its source: sandy soils allow rapid infiltration, supporting at-source approaches to stormwater management, but infiltration rates in soils with significant quantities of clay are much lower, rendering localised stormwater infiltration much more difficult and requiring complex (and presumably expensive) engineering solutions (Argue et al. 2004). Thus, at a purely technical level, the ability to achieve at-source infiltration of stormwater differs between Perth and Melbourne.

The recognition of WSUD in the Western Australia and Victoria SLUP systems may also have been influenced by contrasting priorities of influential actors and organisations. Brown and Clarke (2007) state that organisations such as Melbourne Water and the Victorian Environment Protection Authority, and individual champions, played an important role in the development of the BPEMG stormwater treatment targets and them being afforded mandatory status for new residential development in the Victorian SLUP system. In contrast to the strong identification of WSUD with stormwater treatment targets in Victoria, the Western Australian SLUP system identifies WSUD with, firstly, localised management of urban stormwater and, secondly, a strong hierarchical framework, which links urban water planning with different stages of the planning approval process. Figure 10-2 shows how this process is documented in *Better Urban Water Management* (Western Australia. Western Australian Planning Commission 2008a):

Figure 10-2: Suggested Framework to Link Land Use Planning and Urban Water Planning in Western Australia



Source: Western Australia. Western Australian Planning Commission 2008a, 7

This approach shares key elements with the approach to integrating urban water planning and land use planning in Western Australia suggested a decade ago by Mouritz and Shepherd (2006), shown in Figure 3.1. Shared features include the preparation of urban water management plans at successive stages of the land use planning process and the nomenclature of these plans. Shepherd reiterated her support for this framework more recently (Shepherd 2013). Given the striking similarities in the hierarchical framework advocated by Mouritz and Shepherd, and that described in *Better Urban Water Management* (Western Australia. Western Australian Planning Commission 2008a), it appears that Mouritz and Shepherd directly influenced the Western Australian SLUP system, as it relates to WSUD practice.

The preceding discussion is intended to show that factors such as physical conditions, and the approaches to encouraging WSUD practice promoted by influential actors, vary strikingly between Western Australia and Victoria. According to Brown and Clark's multi-level framework, the configuration of regulatory systems (at their meso level) is determined by a range of factors, at different levels, interacting in complex ways. Brown and Clarke's framework suggests that differing regulatory approaches to WSUD would be likely to emerge from the varying conditions in Victoria and Western Australia, as indeed was observed in the case studies.

10.4 Interpretation of the WSUD Concept by SLUP

According to the case studies, the Western Australian and Victorian SLUP systems exhibit differences, as they relate to WSUD. An important difference is the focus of the Victorian system on the stormwater treatment targets in the BPEMG, whereas the Western Australian system requires the 1-year 1-hour average recurrence interval storm to be infiltrated as close to source as possible, and a range of pre-development stormwater flows and volumes to be maintained. The Western Australian system also emphasises the process of aligning urban water management planning and urban design, particularly via the LWMS and UWMP tools.

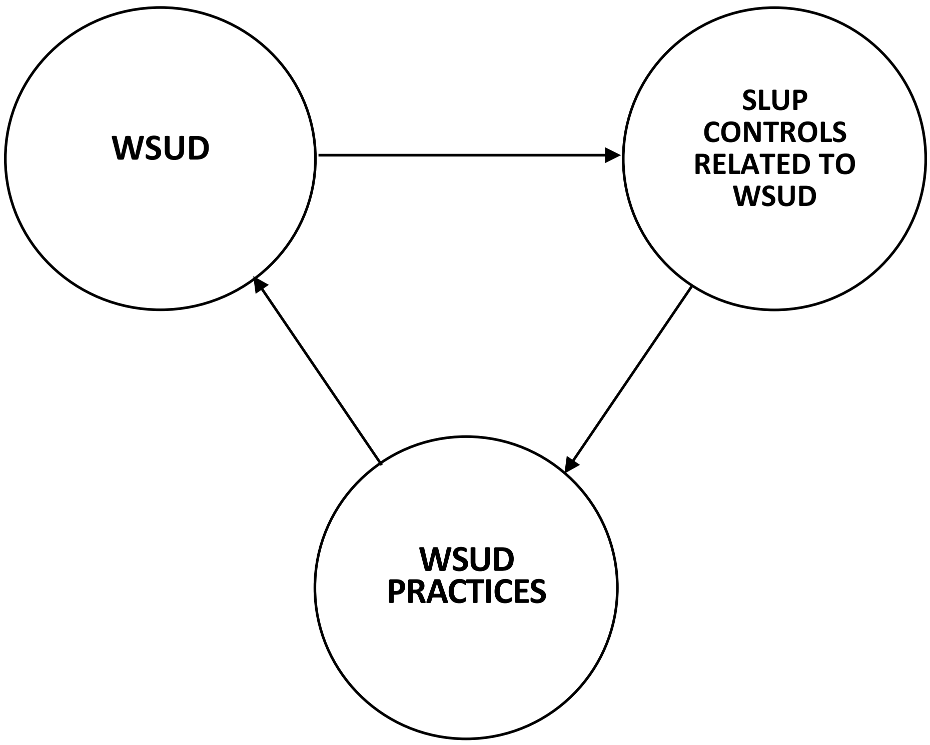
This discussion suggests that the Western Australian and Victorian SLUP systems effectively provide two different interpretations of 'WSUD practice'. SLUP effectively acts as a prism, through which WSUD is interpreted. This suggests that designing SLUP systems to encourage particular WSUD practices is itself an act of interpreting 'WSUD'. This argument may be compared with Ellis, who suggests that sustainable development is best viewed as a concept 'that informs and influences the development and interpretation of international law' (2008, 1)[144]. Based on the analysis of WSUD in Chapter 2, it can similarly be viewed as a concept, which informs the development of SLUP. In both Victoria and Western Australia, specific provisions have been included in SLUP, with the intent of encouraging WSUD practices. That said, the WSUD concept did not, of itself, determine the precise nature of the provisions to include in SLUP. The provisions to include, and those not to include, were a matter of choice. The decision

[144] Another approach to analysing how SLUP interprets WSUD is afforded by the 'legal endogeneity' model, which 'posits that just as much as organizations are affected by legal pressures, so does the state's legal system gradually assimilate business constructions of what the law entails' (Gilad 2014, 136). Legal endogeneity is further described by, for example, Edelman, Uggen, and Erlanger (1999), Talesh (2009) and Edelman et al. (2011). However, legal endogeneity focuses on what it describes as the two-way interaction between the state's legal system and businesses. Ellis considers the relationship between an environmental concept, sustainable development, and international law. Ellis's approach provides a closer analogy to the interaction between the WSUD concept and SLUP being investigated in this thesis, compared with the legal endogeneity model. Thus, Ellis's model is referenced here.

as to which 'WSUD provisions' should be included in SLUP can be viewed as a process of interpreting the WSUD concept, with this decision being influenced by factors at a range of levels, according to Brown and Clarke (2007).

The interpretation of the WSUD concept by SLUP has further consequences. In particular, the specific WSUD practices fostered by SLUP can mediate how WSUD is perceived. Thus, if SLUP emphasises urban stormwater management, particularly via explicit targets, and either does not consider other components of WSUD practice, or considers them marginally, then the tendency to equate 'WSUD' with urban stormwater management practices will be reinforced. According to this analysis, SLUP encourages a particular set of WSUD practices, which, in turn, influences perceptions of the WSUD concept. Figure 10-3 shows this process schematically:

Figure 10-3: Model for SLUP to Mediate Understandings of the WSUD Concept



Source: Original figure

The argument here is that, to the extent that the WSUD concept is interpreted within a particular jurisdiction as a set of SLUP requirements, this regime affects WSUD practices. These practices tend to be accepted over time and this acceptance is itself a barrier to seeing any future vision of WSUD. This process thus acts as a barrier to the acceptance of wider visions of the WSUD concept, which consider the complete urban water cycle, and its integration with land use planning.

10.5 Comparison of the Findings with Earlier Studies

The case study findings can be compared with Gardiner's studies of the implementation of WSUD practices in Australia. According to her perceptive analysis of the WSUD concept (Gardiner 2006; Gardiner 2007), initial WSUD ideas, such as those advocated by Mouritz (1996), were informed by New Urbanism principles, and aimed to integrate urban water management with measures such as increasing public space at the expense of private space; increasing housing density; and encouraging development that combines commercial and residential uses. However, she states (Gardiner 2006; Gardiner 2007) that the application of WSUD to residential development in Australia is typified by the inclusion of large-scale stormwater management practices in public open space corridors, without the broader reorganisation of the public and private realms associated with New Urbanism being adopted.

However, the case studies provided examples where the adoption of WSUD practices extended beyond the limits suggested by Gardiner. Gardiner's findings about the inclusion of large-scale stormwater drainage infrastructure in public open space should be modified to recognise that SLUP also may lead to the implementation of WSUD practices within a subdivision, at a more localised scale than she suggested. In the Western Australian cases, localised WSUD practices were adopted to meet the requirement that stormwater be managed near its source. While acknowledging that Coburg Hill is an infill site, and hence not directly comparable to the greenfield sites discussed by Gardiner, localised WSUD practices were a cost-effective way to comply with the BPEMG targets. Davis Road East, where large-scale stormwater treatment systems were installed in a waterway corridor, represents a case that does conform with Gardiner's findings.

Subsequent to Gardiner's work, Falconer, Newman, and Giles-Corti (2010) stated that the Western Australian government attempted to introduce New Urbanism principles into its planning system via its Liveable Neighbourhoods policy (Western Australia.

Western Australian Planning Commission 2007). However, there is a gap between the intentions of the Liveable Neighbourhoods policy and practice, so that 'the LN[145] code is not delivering the built form that is intended' (Falconer, Newman, and Giles-Corti 2010, 293). Falconer, Newman, and Giles-Corti attribute this gap to what they describe as Liveable Neighbourhoods' lack of specificity about non-residential land requirements and development densities. This reported failure to implement New Urbanism principles indicates that the adoption of WSUD practices at the localised, street-scale, which was particularly evident in the Lane Gardens case, is not contingent on the implementation of the New Urbanism based vision of WSUD proposed by Mouritz (1996), but instead represents a pragmatic, technically driven response to stormwater management requirements in the Western Australian SLUP system.

10.6 Enhancing the Capacity of Statutory Land Use Planning Systems to Encourage WSUD Practices

This section considers how the research findings might inform the further design of SLUP systems, to enhance their capacity to encourage WSUD practices. A well as principles that should be considered when SLUP systems are designed, a process to identify targets that reflect the circumstances in individual jurisdictions is described. This approach is shown to be more likely to encourage WSUD practices than the adoption of uniform targets across different jurisdictions.

10.6.1 The Need to Recognise Local Factors in SLUP Requirements for WSUD

Recommendations about how regulation, including SLUP, could be varied to better support the adoption of WSUD practices have typically been couched in general terms. For example, Campbell (1994) recommends including WSUD concepts in town planning schemes and subdivisions approvals, a broad approach that resembles Wong and Eadie's statement (2000) that the planning approval process should require the implementation of WSUD. Lloyd (2001) suggests including WSUD objectives in the regulatory regime for urban developments and implementing mandatory local development standards to protect the urban water cycle. Lloyd, Wong and Chesterfield (2002) advocate incorporating environmental objectives for stormwater management into planning policy and including related objectives in local government planning

[145] Liveable Neighbourhoods.

schemes. Taylor and Weber (2004) recommend facilitating WSUD by developing policy frameworks that include explicit objectives, which are implemented by appropriate regulatory instruments, including quantitative, measurable targets, in planning controls. Chandler and Eadie (2006) advocate simplifying overly complex regulatory regimes via frameworks that include coherent policies and regulations, and quantitative targets. According to Wong (2006a) practical, equitable performance standards would support the implementation of WSUD practices. Roy et al. (2008) suggest a more explicit legislative mandate for WSUD. Sharma et al. (2012) propose addressing what they describe as inconsistent regulations and guidelines by improving coordination between governments and industry, and preparing consistent policies and guidance. Tjandraatmadja et al (2014) suggest that a state-wide policy and institutional framework to support WSUD should be established, which would include WSUD objectives in the land use planning and approvals system and performance-based targets related to the implementation of WSUD.

These authors all assume that statutory requirements, including SLUP, have the capacity to encourage the implementation of WSUD. This assumption is supported by the findings reported here that SLUP does materially support the adoption of WSUD practices. However, an issue not considered by these authors is the variability of SLUP controls related to WSUD between jurisdictions. The case studies indicate that such controls differ between Western Australia and Victoria, resulting in contrasting interpretations of WSUD practice. Brown and Clarke's multi-level framework (2007) suggests that the varying combinations of factors operating at the macro, meso and micro levels in different jurisdictions are likely to result in varying SLUP controls related to WSUD being adopted. Thus, efforts to enhance the ability of SLUP systems to foster WSUD need to recognise both the varying circumstances in different jurisdictions and Freiberg's insights (2010), which suggest that SLUP regulatory tools come in many forms, ranging from establishing a legal framework via Acts, delegated legislation and regulations, to authorisation using permits and approvals, and the provision of information.

Having identified the need to recognise the specific circumstances in each jurisdiction, including its regulatory architecture, we can now consider general principles to guide the design of SLUP systems, to foster WSUD practices.

10.6.2 Principles to Consider in the Design of SLUP Systems

The discussion earlier in this Chapter indicates that, in order to encourage the adoption of WSUD practices, SLUP systems should be informed by the following principles:

1. SLUP should include a suite of stormwater management targets. These targets should reflect the conditions that prevail within a jurisdiction and could include, for example, requirements related to stormwater quality and management of stormwater flows.
2. The stormwater management targets should refer to a physical scale, which requires stormwater infrastructure to include decentralised assets, to avoid sole reliance on relatively centralised, end of line, systems.

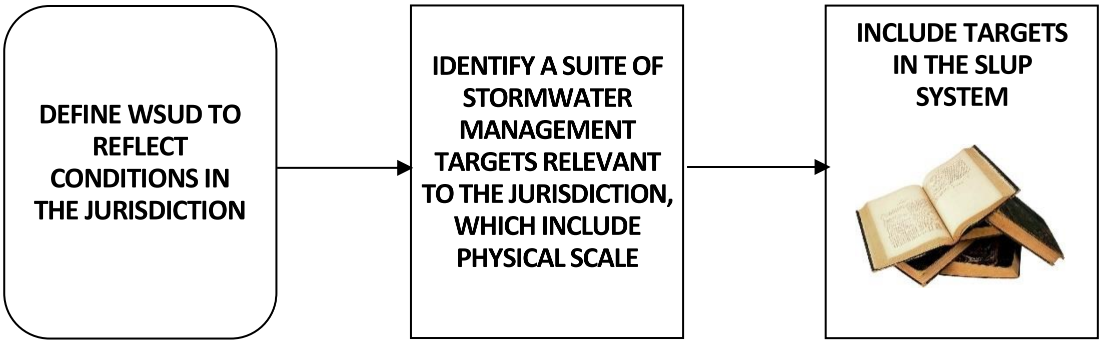
The second principle requires us to consider how a physical scale can be included in SLUP tools. In the Western Australian cases, this scale was specified in qualitative terms, by referring to managing stormwater close to its source. While this approach did encourage the use of decentralised assets in these cases, it is not consistent with either the preference expressed in the survey reported in Chapter 5 for specific, quantitative targets that provide clarity, or Wong's recommendation (2006b, 219) that:

> In order to ensure a level of transparency and consistency in industry participation towards sustainable urban water management, it is desirable that management objectives are defined by quantitative measures of performance and that attaining these objectives can be readily demonstrated.

Ideally, an explicit, quantitative physical scale would be specified, to provide clarity about the extent to which urban water infrastructure should be decentralised. However, it is difficult to identify a precise scale that differentiates centralised and decentralised systems (Sharma et al. 2013, 2096). Further research, to investigate possible ways to include a physical scale in SLUP requirements related to urban water infrastructure, would be useful. Such research should consider how a physical scale could recognise, for example, varying soil types.

To summarise, the preceding discussion shows that SLUP targets designed to encourage WSUD practices in residential developments should recognise the circumstances in a particular jurisdiction and include a physical scale. Figure 10.4 illustrates these points:

Figure 10-4: Recommended Process to Identify Targets to Include in SLUP, to Encourage WSUD in Residential Development



Source: Original figure

While Figure 10.4 shows how a range of stormwater management targets can be identified to foster WSUD practices, there are two issues it does not address, which affect the capacity of SLUP to encourage WSUD. Firstly, the process does not explicitly refer to the broader urban water cycle. Secondly, it does not indicate how targets influence urban design outcomes. These issues will now be considered briefly.

In the case studies, the influence of SLUP on the urban water cycle component of WSUD practice varied. At Coburg Hill, the mandatory installation of rainwater tanks provided some urban water cycle benefits. At Davis Road East, SLUP ensured that the development would have the capacity to utilise recycled water. In the Lane Gardens and Wungong E Stages 3, 4 and 5 cases, SLUP identified the need to treat potentially polluted groundwater discharges. On the other hand, some interviewees suggested that SLUP does not adequately consider the complete urban water cycle. These comments most probably reflect the city-wide water resource planning in Melbourne and Perth carried out by Melbourne Water and the Water Corporation, respectively (McCallum and Boulot 2015). Overall then, the case studies suggest that SLUP is best suited to considering localised urban management issues during the development process. Conditions designed to achieve positive local urban water cycle outcomes can be included in SLUP tools.

The analysis of the case study findings earlier in this chapter suggests that SLUP can influence urban design outcomes at a localised, subdivision scale, via the need to accommodate urban stormwater infrastructure. While acknowledging that decentralised stormwater infrastructure can affect urban form, there is an upper bound to the extent of this influence. However, possible ways to move beyond this limitation are suggested by current research about the WSUD idea, which is discussed in the following section.

10.7 Linking the Research in this Thesis with other Current Research about WSUD

At this point, it is worth briefly considering how the findings of this thesis relate to other research about the WSUD concept. A particularly important current research topic is the possible role of WSUD in mitigating the urban heat island (UHI) effect. The priority of this research recognises the serious public health implications of this effect.

The UHI effect is the elevation of temperatures in urban areas, compared with surrounding rural land use, caused by factors such as the greater absorption of solar radiation by cities, compared with rural areas; reduced evapotranspiration; and heat input from anthropogenic sources (Taha 1997; Arnfield 2003). There are important adverse effects associated with the UHI effect. In particular, there is evidence that the UHI effect exacerbates the increased mortality and morbidity associated with extreme heat events (Alexander and Arblaster 2009).

WSUD has been proposed as a means to mitigate the UHI effect, by methods such as increasing evapotranspiration and increasing the availability of water to support urban vegetation (Mitchell et al. 2008; Coutts et al. 2013). Norton et al. (2015) propose a method to prioritise green infrastructure such as parks, shade trees and vegetated building surfaces to reduce the UHI, and to integrate the results of this assessment with local government planning. Given the interest in using WSUD to mitigate the UHI effect, the potential use of SLUP to foster relevant WSUD practices is worth considering.

The research findings indicate that mandatory, specific targets are more effective at encouraging WSUD practices, compared with more generalised non-binding statements of policy intent. These findings suggest that, where possible, SLUP requirements related to UHI mitigation should include mandatory quantitative targets. For example, instead of referring to the 'implementation of WSUD practices to reduce the UHI effect', a better approach would be to require 'the implementation of WSUD practices that would reduce the maximum temperature of the 99^{th} percentile hot day by 2 degrees'. The use of quantitative targets would depend on the availability of technical procedures with the capacity to assess the ability of proposed measures to meet such targets.

The research findings suggest that SLUP requirements related to WSUD should reflect the circumstances specific to each jurisdiction. This finding would be particularly relevant to provisions intended to foster WSUD practices to mitigate the UHI effect. The different climate regimes experienced by Australian cities (Guest et al. 1999; Australia. Bureau of Meteorology 2016) point to a need to develop SLUP provisions that would recognise these differences. Another factor to consider is how targets related to, for example, stormwater treatment could integrate with targets designed to mitigate the UHI effect. There may be some overlap between the types of targets discussed in this thesis and UHI mitigation targets. However, further research would be required to determine how targets related to urban water cycle management and UHI mitigation could best be combined.

Importantly, WSUD practices designed to mitigate the UHI effect, such as the street trees and vegetated building surfaces suggested by Norton et al. (2015) could increase the capacity of WSUD to influence urban design outcomes. Thus, the influence of WSUD related provisions in SLUP on urban form, within residential subdivisions, could move beyond the strictures associated with accommodating urban stormwater infrastructure. In the absence of the New Urbanism revolution implied by Mouritz (1996), this may be the best way to strength the nexus between management of the urban water cycle and urban design.

10.8 Conclusions

A comparison of the Victorian and Western Australian SLUP systems, based on the case studies, found that a notable difference between them is the inclusion of a sense of physical scale in the stormwater management regime in the latter and its absence in the former. This physical scale, requiring stormwater to be managed close to its source, ensures that SLUP has the capacity to influence the urban stormwater management, urban water cycle and urban water infrastructure components of WSUD practice. Also, decentralised stormwater infrastructure can influence urban form at the street scale, as was the case at Lane Gardens.

The case studies identified examples where decentralised, street-scale WSUD practices have been installed within residential developments. These practices went beyond the installation of large-scale stormwater management measures in public open space corridors identified by Gardiner (2007). The cases demonstrate that, to some extent, SLUP can lead to the adoption of decentralised WSUD practices, without the New Urbanism approach implied by Mouritz's (1996) vision for WSUD.

SLUP systems interpret the WSUD concept. Given the different conditions that prevail across jurisdictions, SLUP systems are likely to interpret the WSUD concept differently. The process where SLUP interprets WSUD, leading to specific WSUD practices, can mediate how the WSUD concept is understood, hindering attempts to apply WSUD as an overarching concept, which considers the entire urban water cycle and links it with land use planning. One approach to broadening the capacity of SLUP to encourage WSUD practices would be to include targets related to mitigating the UHI effect and to integrate these with urban water cycle targets. This approach would have to consider the specific circumstances applying to a jurisdiction and identify suites of targets that acknowledge these conditions.

Chapter 11

CONCLUSIONS

11.1 Introduction

In this Chapter, section 11.2 shows how the research provided answers to the research question. Section 11.3 includes recommendations for further research, based on fresh questions that were identified during this investigation. Some concluding remarks are set out in section 11.4.

11.2 Answers to the Research Question

This thesis addressed the research question:

> *To what extent and in what ways does statutory land use planning in Australian jurisdictions materially influence the implementation of WSUD practices? In other words, how does statutory land use planning facilitate, or hinder, WSUD practice?*

The research answered this question by provided new knowledge, in three separate domains. These are:

1. A new method to investigate how SLUP influences WSUD practices
2. New empirical information about how SLUP influenced SLUP practices, obtained from a survey of participants across Australia and four case studies, (two case studies in each of two Australian jurisdictions)
3. A new understanding of how SLUP systems influence perceptions of the WSUD concept.

The new knowledge in these domains will now be discussed.

A Methodological Advance: A New Method to Investigate how SLUP Influences WSUD Practices

Based on an extensive analysis of the WSUD concept, four distinct components of WSUD practice were identified. These components were shown to represent a conception of WSUD that includes the urban water cycle as a whole and links this cycle with urban design. This four-dimensional interpretation of WSUD practice provides new insights, compared with previous research, which considered WSUD practice as an undifferentiated whole.

Importantly, these components were then used in an extensive empirical investigation of the influence of SLUP on WSUD practices in Australia. The components were a useful empirical tool and provided knowledge that would not otherwise have been obtained.

New Empirical Information about how SLUP Influenced SLUP practices

The research included a survey and four case studies. Together, these provided rich qualitative and quantitative information about how SLUP influences WSUD practices in Australian jurisdictions, which has not been available before.

The findings provided empirical confirmation that SLUP does materially encourage the adoption of WSUD practices. The evidence from the case studies shows that the uptake of WSUD would have been much less comprehensive, in the absence of specific, mandatory SLUP requirements related to WSUD. This finding itself is an important confirmation of assumptions made by water policy analysts. Moreover, it was also confirmed that SLUP provisions that include specific, quantitative targets are more effective at encouraging WSUD practices, compared with provisions that lack such targets. This has significant implications for the design of Australian SLUP systems, given their current reliance on discretionary provisions to promote some aspects of WSUD practice.

Another important insight was that Australian SLUP systems, in some cases, focus on urban stormwater management and do not recognise WSUD as a concept that considers the broader urban water cycle, and links it with urban design. This insight came from rigorous empirical investigation, grounded in the four components of WSUD practice.

The research found that the capacity of stormwater management requirements to encourage the adoption of WSUD practices can be increased by including a physical scale, which requires the use of a combination of centralised and decentralised urban water infrastructure. According to the findings, SLUP can influence the urban design element of WSUD within a subdivision at a localised scale, by requiring that decentralised infrastructure be accommodated within the urban form. The findings about the importance of physical scale also depended on the analytical power of the components of WSUD practice.

New Understanding of How SLUP Systems Influence Perceptions of the WSUD Concept

The research also provided higher level answers to the research question.

SLUP systems interpret the WSUD concept. The Victorian and Western Australian SLUP systems interpret WSUD differently, leading to varying WSUD practices being adopted in these jurisdictions. More generally, given the variable conditions that prevail across jurisdictions, their SLUP systems are likely to interpret the WSUD concept differently.

The WSUD practices fostered by WSUD tend to be accepted over time and this acceptance is itself a barrier to seeing any future vision of WSUD. Instead of questions related to, for example, individual targets in SLUP tools, this may be a more fundamental way in which SLUP influences the adoption of WSUD practices. This is a powerful insight about the connection between SLUP and WSUD practices that emerged from the research.

In summary then, the research provided a new understanding of how SLUP systems could be designed, to improve their capacity to encourage WSUD practices. SLUP should include specific mandatory targets and a sense of physical scale. The complete urban water cycle should be considered and linked with urban design. Also, SLUP systems should recognise the range of physical, institutional, legislative, technical and other factors that apply in a jurisdiction. The research indicates that SLUP systems designed in accordance with these recommendations should strongly encourage a wide range of WSUD practices.

11.3 Areas for Further Research

The research described in this thesis established the importance of including specific targets in statutory land use planning tools, to enhance their ability to foster the adoption of WSUD practices. In particular, the research identified the desirability of specifying a physical scale in stormwater management requirements, so they better address the urban water cycle, urban water infrastructure and urban design components of WSUD practice. Notwithstanding the difficulties associated with identifying a precise scale for centralised and decentralised urban water infrastructure, such research should be a high priority.

Another suggested topic for further research is how targets and objectives related to the urban water cycle could be combined with targets designed to mitigate the urban heat island effect. This research would have to consider how targets related to the urban heat island effect could be developed, which would recognise the widely differing climates in Australia, while also aligning with urban water cycle targets.

Further research should also examine how well, or otherwise, the research findings, and the conclusions drawn from them, apply to jurisdictions other than Western Australia and Victoria. The case studies, and a majority of the participants in the survey, were located in these jurisdictions. This is an acknowledged limitation of this research. Nonetheless, the components of WSUD practice identified in this thesis provides a more powerful lens, compared with prior investigations, and would provide a sound basis for further research about the influence of SLUP systems on the adoption of WSUD practices in other Australian jurisdictions.

11.4 Concluding Remarks

Chapter 2 discussed the evolution of the WSUD concept and compared it with other urban water management models that emerged late in the twentieth century. The element that distinguishes WSUD from these other models was shown to be the close nexus between management of the urban water cycle and the design of urban spaces, which is at the heart of the WSUD concept. However, the research in this thesis indicates that Australian SLUP systems strongly influence urban stormwater management, but that other WSUD outcomes, including those related to urban form, are less apparent.

This thesis shows that it is possible to include targets and objectives in SLUP, to reinforce the connection between the urban water cycle and urban design. This connection must be present, if WSUD is to be clearly distinguished from other urban water cycle models. There is also the possibility that SLUP could include new objectives and targets, related to urban heat island mitigation. This offers the potential to strengthen the extent to which SLUP encourages a broader range of WSUD practices, across all the components identified in this research. While this is an attractive intellectual possibility, identifying and harmonising objectives and targets related to urban stormwater management, the broader urban water cycle, urban water infrastructure and urban heat island mitigation will be a complex policy task, and one set to challenge water researchers and professionals in the future.

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APPENDICES

APPENDIX 1:

QUESTIONNAIRE USED IN THE SURVEY

Question 1 asks about the 'influence' of statutory land use planning on the adoption of WSUD practices. The rating scale allows you to indicate whether you believe that statutory land use planning encourages (i.e. actively supports or promotes), discourages (i.e. inhibits or restrains), or has no influence on the adoption of WSUD practices.

Question 5 refers to 'greenfield' and 'infill' development. Greenfield development refers to the conversion of previously non-urban land on the fringe of metropolitan areas to urban use, whereas infill development refers to new development that occurs within established urban areas

1. This question relates to the influence of statutory land use planning on the adoption of WSUD practices in residential developments. In your experience, how encouraging or discouraging is this influence?

☐ Strongly encouraging
☐ Encouraging
☐ Neither encouraging or discouraging
☐ Discouraging
☐ Strongly discouraging
☐ Not sure

2. Please comment about the reasons for your answer to the previous question. You can support your comments with examples.

3. To what extent do statutory land use planning controls that include specific quantitative targets encourage the adoption of WSUD practices in residential developments, compared with controls that do not include specific quantitative targets? Please base your answer on your experience.

☐ To a much larger extent
☐ To a larger extent
☐ About the same
☐ To a smaller extent
☐ To a much smaller extent
☐ Not sure

4. Please comment about the reasons for your answer to the previous question. You can support your comments with examples.

5. To what extent does statutory land use planning encourage the adoption of WSUD practices in greenfield residential developments, compared with infill residential developments? Please base your answer on your experience.

- ☐ To a much larger extent
- ☐ To a larger extent
- ☐ About the same
- ☐ To a smaller extent
- ☐ To a much smaller extent
- ☐ Not sure

6. Please comment about the reasons for your answer to the previous question. You can support your comments with examples.

Question 7 asks about the 'influence' of statutory land use planning on the adoption of components of WSUD practice. The rating scale allow you to indicate whether you believe that statutory land use planning encourages (i.e. actively supports or promotes), discourages (i.e. inhibits or restrains), or has no influence on the adoption of the components of WSUD practice.

7. This question is about the influence of statutory land use planning on the adoption of components of WSUD practice in residential developments. In your experience, how encouraging or discouraging is this influence on each component listed below?[146]

[146] The on-line questionnaire included an introduction, which defined the components of WSUD practice as shown in Table 2.4, on page 42. On the advice of the panel of urban water management and land use planning professionals consulted during the development of the components, these definitions were supplemented by the additional information about the components included in questions 7 and 9. This additional information was intended to ensure the participants properly understood the rationale for the components.

	Strongly discouraging	Discouraging	Neither encouraging or discouraging	Encouraging	Strongly encouraging	Not sure
The quantity, quality and frequency of urban stormwater runoff are managed to mitigate flood risks and adverse impacts on receiving environments	☐	☐	☐	☐	☐	☐
Urban water resources are conserved, managed and used on a fit-for-purpose basis to maximise the benefit they provide to the community	☐	☐	☐	☐	☐	☐
Urban water infrastructure includes a combination of centralised and decentralised systems	☐	☐	☐	☐	☐	☐
Urban water management is integrated with the urban design process and influences its outcomes	☐	☐	☐	☐	☐	☐

8. Please comment about the reasons for your answer to the previous question. You can support your comments with examples.

9. In your opinion, how important is each component of WSUD practice listed below?

	Unimportant	Slightly important	Moderately important	Important	Very important	Not sure
The quantity, quality and frequency of urban stormwater runoff are managed to mitigate flood risks and adverse impacts on receiving environments	☐	☐	☐	☐	☐	☐
Urban water resources are conserved, managed and used on a fit-for-purpose basis to maximise the benefit they provide to the community	☐	☐	☐	☐	☐	☐
Urban water infrastructure includes a combination of centralised and decentralised systems	☐	☐	☐	☐	☐	☐
Urban water management is integrated with the urban design process and influences its outcomes	☐	☐	☐	☐	☐	☐

10. Please comment about the reasons for your answer to the previous question. You can support your comments with examples.

APPENDIX 2:

SEMI-STRUCTURED INTERVIEW GUIDE USED IN THE CASE-STUDIES

INTRODUCTION

1. Explain the research, including the contribution this interview will make to the research.
2. Ask the interviewee about the role their organisation played in the case study.
3. Ask the interviewee about their role in relation to the case study.

INFLUENCE OF STATUTORY LAND USE PLANNING ON THE IMPLEMENTATION OF WSUD PRACTICES

4. In your opinion, what were the main WSUD practices that were included in the development?

5. In the development:
    a. What was the range of factors that influenced the adoption of WSUD practices, and where did statutory land use planning fit in that range?
    b. How did statutory land use planning influence the adoption of WSUD practices?
    c. Were there features of the statutory land use planning system that enhanced its ability to influence the adoption of WSUD practices?
    d. Were there features of the statutory land use planning system that hindered its ability to influence the adoption of WSUD practices?

6. This question relates to the influence of statutory land use planning on the adoption of WSUD practices in the development. In your experience, how encouraging or discouraging was this influence?

Strongly encouraging	☐
Encouraging	☐
Neither encouraging or discouraging	☐
Discouraging	☐
Strongly discouraging	☐

7. What were your main reasons for this rating?

INFLUENCE OF STATUTORY LAND USE PLANNING ON THE COMPONENTS OF WSUD PRACTICE

Influence of Statutory Land Use Planning on the Urban Stormwater Management Component of WSUD Practice

8. In the development:
    a. How did statutory land use planning influence this component of WSUD practice?
    b. Were there features of the statutory land use planning system that enhanced its ability to influence this component of WSUD practice?
    c. Were there features of the statutory land use planning system that hindered its ability to influence this component of WSUD practice?

9. In your opinion, the influence of statutory land use planning on this component of WSUD practice was:

Strongly encouraging	☐
Encouraging	☐
Neither encouraging or discouraging	☐
Discouraging	☐
Strongly discouraging	☐

10. What were your main reasons for this rating?

Influence of Statutory Land Use Planning on the Urban Water Cycle Component of WSUD Practice

11. In the development:
    a. How did statutory land use planning influence this component of WSUD practice?
    b. Were there features of the statutory land use planning system that enhanced its ability to influence this component of WSUD practice?
    c. Were there features of the statutory land use planning system that hindered its ability to influence this component of WSUD practice?

12. In your opinion, the influence of statutory land use planning on this component of WSUD practice was:

Strongly encouraging	☐
Encouraging	☐
Neither encouraging or discouraging	☐
Discouraging	☐
Strongly discouraging	☐

13. What were your main reasons for this rating?

Influence of Statutory Land Use Planning on the Urban Water Infrastructure Component of WSUD Practice (i.e. the adoption of a combination of centralised and decentralised urban water systems)

14. In the development:
    a. How did statutory land use planning influence this component of WSUD practice?
    b. Were there features of the statutory land use planning system that enhanced its ability to influence this component of WSUD practice?
    c. Were there features of the statutory land use planning system that hindered its ability to influence this component of WSUD practice?

15. In your opinion, the influence of statutory land use planning on this component of WSUD practice was:

    Strongly encouraging ☐
    Encouraging ☐
    Neither encouraging or discouraging ☐
    Discouraging ☐
    Strongly discouraging ☐

16. What were your main reasons for this rating?

Influence of Statutory Land Use Planning on the Urban Design Component of WSUD Practice (i.e. urban design outcomes are influenced by urban water cycle management)

17. In the development:
    a. How did statutory land use planning influence this component of WSUD practice?
    b. Were there features of the statutory land use planning system that enhanced its ability to influence this component of WSUD practice?
    c. Were there features of the statutory land use planning system that hindered its ability to influence this component of WSUD practice?

18. In your opinion, the influence of statutory land use planning on this component of WSUD practice was:

    Strongly encouraging ☐
    Encouraging ☐
    Neither encouraging or discouraging ☐
    Discouraging ☐
    Strongly discouraging ☐

19. What were your main reasons for this rating?

CLOSING QUESTIONS

20. Are there any further comments you would like to add?
21. Are there further documents I should obtain?
22. Suggestions for additional interviewees?

APPENDIX 3:

DOCUMENTS REVIEWED DURING THE CASE STUDIES

BOTH VICTORIAN CASES

Victoria Planning Provisions Clause 56.07, Integrated Water Management.

Urban stormwater: best practice environmental management guidelines. 1999. Victoria. Stormwater Committee. Melbourne, Victoria.

Using the integrated water management provisions of Clause 56 – Residential subdivision. 2006. Victoria. Department of Sustainability and Environment. East Melbourne, Victoria.

COBURG HILL, VICTORIA

Statutory Planning Documents

City of Moreland Planning Scheme. (Available online at http://planning-schemes.delwp.vic.gov.au/schemes/moreland).

City of Moreland Planning Scheme Amendment C111. This amendment includes Development Plan Overlay DPO 10 and the associated Schedule (the suite of documents that effected the amendment is available online at http://planning-schemes.delwp.vic.gov.au/updates-and-amendments/amendment?id=D7D0307BFEABCF2ECA2575A50018CAF5).

173-199 Elizabeth Street Coburg Environmental Management Plan. 2009. Ark Resources. South Melbourne, Victoria. (This document is part of the Development Plan prepared in accordance with Schedule 10 to Development Plan Overlay DPO 10).

173 Elizabeth Street Coburg Stormwater Drainage Master Plan. 2009. Neil M Craigie Pty Ltd. Croydon, Victoria. (This document is part of the Development Plan prepared in accordance with Schedule 10 to Development Plan Overlay DPO 10).

Development Plan Coburg Hill 173-199 Elizabeth Street, Coburg. 2010. Collie Pty Ltd. Melbourne, Victoria.

Report to Support Stage 1A Permit Application, Kodak Redevelopment Site. 2011. CPG. Melbourne, Victoria (not public domain).

Kodak Site Redevelopment Drainage and Stormwater Management Strategy to Support Permit Applications. 2011. CPG. Melbourne, Victoria (not public domain).

Planning permits for stages of the Coburg Hill development.

Other documents

Moreland City Council Objectives for Redevelopment of the Former Coburg Hill Site. 2006. (Available online at http://www.moreland.vic.gov.au/globalassets/areas/strategic-planning/kodak--objectives-for-redevelopment-of-the-former-kodak-site.pdf).

Stormwater Targets: Stormwater quality targets for the City of Moreland. 2012. AECOM. Melbourne, Victoria.

Coburg Hill – Clause 56.07 in action. 2012. (Available online at https://www.clearwater.asn.au/resource-library/case-studies/coburg-hill-clause-5607-in-action.php).

DAVIS ROAD EAST, VICTORIA

Statutory Planning Documents

City of Wyndham Planning Scheme. (Available online at http://planning-schemes.delwp.vic.gov.au/schemes/wyndham).

Riverdale Precinct Structure Plan, June 2013. Victoria. Growth Areas Authority. Melbourne, Victoria.

Riverdale Precinct Structure Plan, September 2014. Victoria. Metropolitan Planning Authority. Melbourne, Victoria.

City of Wyndham Planning Scheme Amendment C176. This amendment (among other things), incorporates the Riverdale Precinct Structure Plan in the City of Wyndham Planning Scheme (the suite of documents that effected the amendment is available online at http://planning-schemes.delwp.vic.gov.au/updates-and-amendments/amendment?id=971BFDF211E301E1CA257B7F00069E08).

Planning permit WYP6217/12, 14 November 2014, allowing subdivision of the Davis Road East site for residential purposes.

Surface Stormwater Management Strategy, Davis Road East, Stockland, January 2015. Alluvium. Richmond, Victoria. This strategy was prepared in accordance with planning permit WYP6217/12 (not public domain).

Other documents

Delivering Melbourne's Newest Sustainable Communities. 2010. Victoria. Department of Planning and Community Development. East Melbourne, Victoria.

Growth Corridor Plans, Chapter 4, West Corridor Plan. 2012. Victoria. Growth Areas Authority. Melbourne, Victoria.

Wyndham North Stormwater Management Strategy. 2013. Spiire Australia. Melbourne, Victoria.

Wyndham North Precinct Structure Plans Background Report June 2013. Victoria. Growth Areas Authority. Melbourne, Victoria.

Wyndham Planning Scheme Amendments C175 C176 C177 Panel Report. Planning Panels Victoria. Melbourne, Victoria.

Minutes of Wyndham City Council meetings, various dates from 2011 – 2013. (Minutes of Wyndham City Council meetings are available online at https://councilpapers.wyndham.vic.gov.au/).

BOTH WESTERN AUSTRALIAN CASES

State Planning Policy 2.9: Water Resources.

Better Urban Water Management. 2008. Western Australia. Western Australian Planning Commission. Perth, Western Australia.

Interim: Developing a local water management strategy. 2008. Western Australia. Department of Water. Perth, Western Australia.

Urban water management plans: guidelines for preparing plans and for complying with subdivision conditions. 2008. Western Australia. Department of Water, Perth, Western Australia.

Southern River/Forrestdale/Brookdale/Wungong District Structure Plan. 2001. Western Australia. Western Australian Planning Commission. Perth, Western Australia.

LANE GARDENS, WESTERN AUSTRALIA

Statutory Planning Documents

City of Gosnells Town Planning Scheme No.6. Available online at http://www.gosnells.wa.gov.au/Building_and_development/Planning_the_City/Town_Planning_Scheme_No._6.

Southern River Outline Revised Development Plan Precinct 2 (Phase 1). 2006. Available online at http://www.gosnells.wa.gov.au/files/sharedassets/public/pdfs/plannning_and_development/revised_odp_srp2.pdf

Bletchley Park Local Water Management Strategy. 2005. GHD. Perth, Western Australia.

Modification to Southern River Precinct 2 Phase 1 Outline Development Plan, 21 July 2014 (not public domain).

Bletchley Park Local Water Management Strategy Amendments. 2014. GHD, Perth, Western Australia.

Bletchley Park, Lane Gardens, Urban Water Management Plan. 2014. Essential Environmental, Perth, Western Australia. (Not public domain).

Western Australian Planning Commission subdivision approval No. 148832, 14 February 2014. (Not public domain).

Other documents

Minutes of City of Gosnells meetings, various dates from 2002 to 2014. (Minutes of City of Gosnells Council meetings are available online at http://www.gosnells.wa.gov.au/About_us/Council/Agenda_and_minutes).

WUNGONG PRECINCT E STAGES 3/4/5

Statutory Planning Documents

Wungong Urban Water Redevelopment Scheme 2007. Available online at http://cdn.mra.wa.gov.au/production/961b4a25b410b24fbb4389cd20b7e902/wungong-urban-water-redevelopment-scheme.pdf.

Ministerial Statement 762 by the Minister for the Environment, February 2008. Available online at http://www.epa.wa.gov.au/sites/default/files/1MINSTAT/Statement%20No%20%20762.pdf.

Armadale Redevelopment Authority Urban Water Management Policy (adopted by the Armadale Revelopment Authority in August 2008). Available online at http://cdn.mra.wa.gov.au/production/495cc216ce5111ad3c4f740c5dd24dce/wungong-urban-water-management-policy.pdf.

Local Water Management Strategy Wungong Urban Water Precinct E. 2008. JDA, Perth, Western Australia.

Wungong Precinct E Structure Plan 2009. Available online at http://cdn.mra.wa.gov.au/production/5b43feaef2f22b6957ba303b7125b40a/precinct-e.pdf.

Western Australian Planning Commission subdivision approval No. 140432, 30 June 2010. (Not public domain).

Wungong Precinct E Stage 3, 4 & 5 Urban Water Management Plan. 2011. Emerson Stewart, Perth, Western Australia. (Not public domain).

Other documents

Neerigan Brook South Main Drain Design Report Stage 1 – Eleventh Road to Eighth Road. 2010. Emerson Stewart. Perth, Western Australia.

Wungong Urban Water Project – A major innovation in alternative urban water supply in WA. 2010. Presentation available online via the NewWAterWays website at http://www.newwaterways.org.au/downloads/nww-speaker-series/2010%2008%20-%20Wungong%20Urban%20Water.pdf.

APPENDIX 4:

CONFERENCE PAPER

The following peer-reviewed paper was presented at the Stormwater 2016 Conference (Williams, Don, 2016, *Room for Improvement: The Influence of Statutory Land Use Planning on the Adoption of Water Sensitive Urban Design Practices in Australia*, Stormwater 2016 Conference, Gold Coast, Queensland, August 29 – 2 September 2016).

Room for Improvement: The Influence of Statutory Land Use Planning on the Adoption of Water Sensitive Urban Design Practices in Australia

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Regulation, including statutory land use planning law, has been seen as an important way to encourage the adoption of water sensitive urban design (WSUD) practices. Despite this, there are challenges in understanding how statutory land use planning influences the uptake of WSUD practices, and how planning frameworks could be redesigned, to better support WSUD.

The influence of statutory planning was investigated in a survey of water resource and planning professionals. The survey examined the degree to which statutory land use planning does influence WSUD practice; the importance of including quantitative targets in statutory planning requirements; the comparative influence of statutory land use planning at greenfield and infill sites; and how statutory land use planning influences four specific components of WSUD practice.

Identifying specific components of WSUD practice, and examining how statutory land use planning influences them, provided more detailed insights than previous studies, which typically considered WSUD as an undifferentiated whole.

The survey results indicate that statutory land use planning does encourage the adoption of some WSUD practices, while suggesting ways to refine planning frameworks, so they better support the implementation of WSUD. A key finding was that current Australian statutory land use planning frameworks do not adequately recognise WSUD as a concept that encompasses the whole urban water cycle, and that strongly links water management and urban design.

1. Introduction

Water sensitive urban design (WSUD) may be defined as 'an approach to urban planning and design that integrates the management of the total water cycle into the land use and development process' (South Australia. Department of Environment Water and Natural Resources 2013, 5). This definition of WSUD extends beyond stormwater management and considers the interactions between urban built form and the urban water cycle, including the potable water, wastewater and stormwater streams, as recommended by Wong (2006a).

Key benefits of WSUD are reported to include maintaining and improving the condition of urban streams, building resilience to climate change, efficient use of water resources, and ensuring that decisions about urban water management are informed by the local social, cultural and environmental context (Mouritz 1996; Newman 2001; Mitchell 2006). This suggests that WSUD has the potential to contribute to the ecological, social and economic development of cities.

A review by Wong (2006b) identifies the regulatory framework; assessment and costing; community acceptance and governance; and technology and design as key factors that influence the implementation of WSUD in Australia. This range of factors is similar to that identified by Lloyd (2001).

Examining the influence of all these factors would be beyond the scope of the investigation described in this paper, which focused on the regulatory framework. The importance of an appropriate regulatory framework in encouraging the adoption of WSUD has been identified by a number of authors (Gardiner and Hardy 2005; Chandler and Eadie 2006; Roy et al. 2008). Recognising this, jurisdictions across Australia have included, to varying degrees, requirements in their land use planning systems that are intended to encourage the adoption of WSUD practices (McCallum and Boulot 2015). Despite this, there is a lack of understanding about how land use planning laws influence the adoption of WSUD (Sharma et al. 2012, 344).

Thus, advocates of WSUD face the dual challenges of improving current knowledge about how land use planning affects the implementation of WSUD, and understanding how land use planning frameworks can be reformed, to support better the adoption of WSUD.

This paper describes an investigation that was carried out to address these challenges, by assessing how statutory land use planning influences the adoption of a range of WSUD practices. In the investigation, 'statutory land use planning' was defined as the statutory regulation of land use and development, to meet public policy objectives. This term includes primary land use planning legislation; regulations and statutory policies made under primary planning legislation; the development approvals process; and approvals for individual developments. The investigation considered the implementation of WSUD in residential developments, to avoid the potential uncontrolled variability associated with studying the implementation of WSUD in a range of different land uses.

2. METHOD

The investigation was carried out by surveying participants from the government, water utility, private and research sectors, about the influence of statutory land use planning on WSUD practices. The survey is part of a wider research program, which includes a number of case studies. These case studies are examining how statutory land use planning affected the adoption of WSUD practices at residential developments. Gathering evidence by these two methods (that is, the survey and the case studies) is intended to enhance the robustness of the research findings.

The survey included a number of steps (Sue and Ritter 2007, 2):

Defining the sample population and choosing a sampling frame

The sample population consisted of professional water resource management and urban planning staff from organisations in Australia affiliated with the Cooperative Research Centre for Water Sensitive Cities (CRCWSC), who were was accessible via the CRCWSC's email contact lists. The sampling frame (that part of the population from which samples can be drawn) consisted of the entire population.

Designing a data collection strategy

Data was gathered by distributing an email with an invitation to take part in the survey, on an opt-in basis. Online surveys are a suitable method when the sample is large and widely dispersed geographically (Sue and Ritter 2007, 5), conditions that applied in this investigation.

Developing a questionnaire

The questionnaire was designed to examine a series of questions related to the influence of statutory land use planning on the adoption of WSUD practices. Demographic questions were included in the questionnaire. The questionnaire included both rating-scale (quantitative) and open-ended (qualitative) questions. The rating-scale questions used a 5 point scale, as 'it is safe to say that 4 or 5 point scales will be serviceable for most attitude or opinion data collection' (Sue and Ritter 2007, 51). Open-ended questions were included, which asked participants to comment about the ratings that they provided. Open-ended questions also provide opportunities for unanticipated information to be obtained (Sue and Ritter 2007, 44; Fowler 2014, 88).

Collecting and managing data

An invitation to take part in the survey was distributed by the CRCWSC in 18 August 2015. Data was collected via an anonymous online questionnaire, from 18 August 2015 to 13 October 2015. The number of recipients of the invitation was estimated to be in the range 810 – 950 (personal communication, S Pogonowski, CRCWSC Communications Officer). Quantitative and qualitative data were recorded on a survey host managed by the CRCWSC. Data were transferred from this host to an Excel database. The quantitative information was also transferred to the SPSS software package for statistical analysis.

Part of the survey examined how statutory land use planning influences specific 'components' of WSUD practice. These components may be thought of a set of outcomes, or results, which should be present in a development when WSUD has been implemented.

These components are as follows:

Table 1: Components of WSUD Practice

Component of WSUD practice	Rationale for the component
The quantity, quality and frequency of urban stormwater runoff are managed to mitigate flood risks and adverse impacts on receiving environments.	Managing stormwater runoff is a core element of WSUD. Mitigating the adverse impacts of stormwater runoff is a fundamental part of WSUD practice. **This component focuses on urban stormwater management**
Urban water resources are conserved, managed and used on a fit for purpose basis to maximise the benefit they provide to the community.	This component reflects the broad intent of WSUD to protect the urban water cycle from the impacts of urban development. The urban water cycle considers the potable water, wastewater and stormwater streams, and their interactions (Wong 2006a). **This component focuses on the urban water cycle**
Urban water infrastructure includes a combination of centralised and decentralised systems.	A portfolio of centralised and decentralised infrastructure provides local social, environmental and amenity benefits, and enhances system resilience. **This component focuses on urban water infrastructure**
Urban water management is integrated with the urban design process and influences its outcomes	WSUD explicitly links urban design and the urban water cycle. It follows that urban water management should be considered throughout the urban design process and should influence urban design outcomes. **This component focuses on urban design**

Collectively, these components of WSUD practice relate to the urban water cycle and its interaction with urban built form, and are consistent with the definition of WSUD adopted in this investigation.

There may be some overlap between these components. For example, urban stormwater management does relate to the management of the urban water cycle as a whole. Integrating urban water management with the urban design process may also improve the management of stormwater runoff and identify increased opportunities to use decentralised infrastructure. However, such overlap does not negate the focus on an important WSUD outcome that each component provides, or prevent them being used for analytical purposes. The interpretation of the sustainable development concept provides an analogy. While the 'three-legged stool' interpretation of sustainable development includes three components that overlap and interact in complex ways (economic, environmental and social) the three-legged stool interpretation is widely used (Sneddon, Howarth and Norgaard 2006). Thus, the implementation of a broad concept, such as WSUD, or sustainable development, can be investigated via a number of outcomes or components, even if there is some overlap between these components.

The components of WSUD practice provide a framework to investigate influences on the implementation of WSUD that permits closer analysis than previous investigations, which typically considered WSUD as an undifferentiated whole.

3. RESULTS AND DISCUSSION

3.1 Responses to the survey

Fifty one responses to the survey were received. The following table provides information about these responses.

Table 2: Information about the Responses to the Survey

Number of responses that answered all the rating scale questions and included comments about all, or some, of the ratings	40
Number of responses that answered all the rating scale questions and did not include comments about the ratings	6
Number of responses where the participant ceased answering the rating-scale questions part way through the questionnaire, and included comments about all, or some, of the ratings that were provided	3
Number of responses where the participant ceased answering the rating-scale questions part way through the questionnaire and did not include comments about the ratings that were provided	2
Total number of responses	51

The 51 responses correspond to a response rate in the range 5.4 – 6.3 percent. This is considered to be reasonable for the group invited to take part in the survey (personal communication, S Pogonowski, CRCWSC Communications Officer).

Demographic information for the respondents is as follows:

Table 3: Demographic Information about the Survey Participants

<table>
<tr><td colspan="9">JURISDICTION</td></tr>
<tr><td>ACT</td><td>New South Wales</td><td>Northern Territory</td><td>Queensland</td><td>South Australia</td><td>Tasmania</td><td>Victoria</td><td>Western Australia</td><td>No answer</td></tr>
<tr><td>3</td><td>4</td><td>0</td><td>5</td><td>1</td><td>0</td><td>20</td><td>13</td><td>5</td></tr>
</table>

<table>
<tr><td colspan="6">EMPLOYMENT SECTOR</td></tr>
<tr><td>Private sector</td><td>Local Government</td><td>State Government</td><td>Water Utility/ Corporation</td><td>Research</td><td>No Answer</td></tr>
<tr><td>9</td><td>16</td><td>9</td><td>9</td><td>2</td><td>6</td></tr>
</table>

<table>
<tr><td colspan="8">PROFESSIONAL TRAINING AND EXPERIENCE</td></tr>
<tr><td>Urban/ Land Use/ Statutory Planning</td><td>Engineering</td><td>Natural Resource Management</td><td>Science</td><td>Management Business Economics</td><td>Law</td><td>Urban Design Architecture Landscape Architect</td><td>No Answer</td></tr>
<tr><td>18</td><td>7</td><td>5</td><td>6</td><td>3</td><td>1</td><td>5</td><td>6</td></tr>
</table>

<table>
<tr><td colspan="5">ROLE IN WATER CYCLE MANAGEMENT</td></tr>
<tr><td>Stormwater/ Waterways</td><td>Water Supply</td><td>Land Use Planning Urban Development</td><td>Total Water Cycle Management</td><td>No answer</td></tr>
<tr><td>10</td><td>2</td><td>22</td><td>11</td><td>6</td></tr>
</table>

The respondents came from a range of jurisdictions, employment sectors, training and professional roles. This diversity means that the responses provide a broad and deep set of insights into the influence of statutory land use planning on WSUD practices in Australia.

The responses to the survey questions are summarised and discussed below.

3.2 Influence of statutory land use planning on the adoption of WSUD practices

The survey included the question:

This question relates to the influence of statutory land use planning on the adoption of WSUD practices in residential developments. In your experience, how encouraging or discouraging is this influence?

The respondents were also asked to comment about their answers. The answers were as follows:

Table 4: Responses to Question about the Influence of Statutory Land Use Planning on the Adoption of WSUD Practices in Residential Developments

Response	Number of responses
Strongly encouraging	9
Encouraging	28
Neither encouraging or discouraging	10
Discouraging	3
Strongly discouraging	0
Not sure	1

These ratings indicate that, according to the majority of the survey participants, statutory land use planning materially encourages the adoption of WSUD practices. From 51 responses, 37 were either *encouraging* or *very encouraging*, compared with only three *discouraging* responses and no *strongly discouraging* responses. The favourable influence of statutory land use planning was generally attributed to it making the adoption of WSUD practices a legally-binding obligation, as expressed by comments such as ‘It encourages because it makes it a requirement’.

That said, 13 respondents provided a *discouraging* or *neither encouraging or discouraging* rating. Comments linked these unfavourable or neutral ratings with two factors. Firstly, some comments suggested that, while statutory land use planning systems include requirements related to WSUD, corresponding implementation procedures, such as capacity building and enforcement measures, are lacking. Secondly, a number of comments suggested that current statutory land use planning regimes do not include sufficient requirements mandating the adoption of WSUD practices.

The general term ‘residential development’ was used in the questionnaire, so it is not possible to draw conclusions about the influence of statutory land use planning on residential developments of different physical scales from the survey.

Taken as a whole, the ratings and the supporting comments suggest that statutory land use planning materially encourages the adoption of WSUD practices.

3.3 Influence of statutory land use controls that include specific quantitative targets, compared with controls without quantitative targets

The survey included the question:

To what extent do statutory land use planning controls that include specific quantitative targets encourage the adoption of WSUD practices in residential developments, compared with controls that do not include specific quantitative targets?

The respondents were also asked to comment about their answers. The answers were as follows:

Table 5: Responses to Question about the Influence of Statutory Land Use Planning Controls that Include Specific Quantitative Targets, Compared with Controls without Quantitative Targets

Response	Number of responses
To a much larger extent	13
To a larger extent	22
About the same	6
To a smaller extent	0
To a much smaller extent	1
Not sure	9

The ratings provided by the respondents strongly support the idea that statutory land use controls with specific quantitative targets influence WSUD practices to a greater extent than controls that lack such targets. The total of 35 *much larger extent* and *larger extent* responses contrasts sharply with the single *much smaller extent* answer. The comments consistently suggested that quantitative targets provide clear, unambiguous direction to all participants, as summarised by the comment that: 'Quantitative controls are easier to administer by all parties as they know where the goal posts are and they can aim for them accordingly. In short, it removes subjectivity and uncertainty for all parties involved in statutory planning'.

The ratings and comments indicate that statutory land use planning controls, which include specific quantitative targets, encourage the adoption of WSUD practices to a larger extent than controls lacking such targets.

3.4 Influence of Statutory Land Use Planning at Greenfield Developments, Compared with Infill Developments

The survey included the question:

To what extent does statutory land use planning encourage the adoption of WSUD practices in greenfield residential developments, compared with infill residential developments?

The respondents were also asked to comment about their answers. The answers were as follows:

Table 6: Responses to Question about the Influence of Statutory Land Use Planning in Greenfield Developments, Compared with Infill Developments

Response	Number of responses
To a much larger extent	14
To a larger extent	19
About the same	7
To a smaller extent	1
To a much smaller extent	1
Not sure	9

The ratings indicate that statutory land use planning encourages WSUD practices to a greater extent at greenfield developments, compared with infill developments. The comments suggested that this can largely be attributed to two causes.

Firstly, it was stated that statutory land use planning requirements that relate to WSUD, which apply to greenfield developments, may not apply to infill developments. Examples of such requirements were reported to include Clause 56.07 of the Victoria Planning Provisions and Western Australia's *Better Urban Water Management* policy. Clause 56.07 includes requirements designed to encourage the adoption of WSUD practices. The clause applies to the subdivision of land to create residential lots, the typical pathway for greenfield development, but does not apply to, for example, the construction of two or more dwellings on a lot, a process by which infill development can occur. *Better Urban Water Management* provides a framework that supports the implementation of WSUD. It generally applies to greenfield development, but not infill development, 'unless significant water management issues are present' (Western Australian Planning Commission 2008, vii).

Secondly, infill sites may be subject to physical constraints, such as limited space and existing infrastructure, which restrict the ability to install WSUD measures, whereas greenfield sites have 'the ability to accommodate measures on a clean slate without the encumbrances of existing conditions'.

These factors are not mutually exclusive and some comments cited both. The ratings and comments are consistent, both indicating that statutory land use planning encourages WSUD practices to a greater extent at greenfield developments, compared with infill developments.

3.5 Influence of Statutory Land Use Planning on the Components of WSUD Practice

The survey included the question:

This question is about the influence of statutory land use planning on the adoption of components of WSUD practice in residential developments. In your experience, how encouraging or discouraging is this influence on each component listed below?

The respondents were also asked to comment about their answers. The answers were as follows:

Table 7: Responses to Question about the Influence of Statutory Land Use Planning on the Components of WSUD Practice

Component	Strongly discouraging	Discouraging	Neither Encouraging or Discouraging	Encouraging	Strongly encouraging	Not sure	No answer
Urban stormwater management	1	3	4	19	19	1	4
Urban water cycle	2	10	15	17	2	1	4
Urban water infrastructure	0	10	23	8	2	4	4
Urban design	1	5	20	14	6	1	4

The ratings indicate that, according to the respondents, the urban stormwater management component is most influenced by statutory land use planning, with all the other components being less influenced. There appear to be differences between the ratings for the other components, although these are less distinct than the clear differences between the stormwater management component and the others. Statistical analysis of the results, using the Wilcoxon signed ranks test (Wilcoxon 1945; Rey and Neuhäuser 2011), indicates that the higher ratings for the stormwater management component differ from the ratings for the other components, at both the 5% and 1% levels of significance. The analysis also shows that the higher ratings for the urban design component, compared with the ratings for the urban water infrastructure component, differ at the 5% significance level. The other differences are not statistically significant.

The comments about the ratings suggested that statutory land use planning requirements mainly relate to managing urban stormwater and there are comparatively few requirements that can influence the other components of WSUD practice. This view was summarised by the comments 'Current requirements…is for water quantity and quality only and does not encourage the other outcomes' and 'There is little enablement of alternative urban water practices through the statutory planning process'.

The ratings and comments suggest that current statutory land use planning systems narrowly focus on urban stormwater management and do not adequately consider, or influence, the other components of WSUD practice. These results provide information about the limitations of current Australian statutory land use planning systems. According to the survey respondents, the broad concept of WSUD, encompassing the entire urban water cycle and strongly linking water management and urban design, is not manifest in either current statutory land use planning requirements, or their influence on WSUD practices.

3.7 Importance of the Components of WSUD Practice

The survey included the question:

In your opinion, how important is each component of WSUD practice listed below?

The respondents were also asked to comment about their answers. The answers to this question were as follows:

Table 8: Responses to Question about the Importance of the Components of WSUD Practice

Component	Unimportant	Slightly Important	Moderately Important	Important	Very Important	Not sure	No answer
Urban stormwater management component	0	1	2	9	35	0	4
Urban water cycle component	0	0	6	13	28	0	4
Urban water infrastructure component	0	3	6	18	14	6	4
Urban design component	0	0	2	14	31	0	4

Essentially, the respondents identified the urban stormwater management, urban water cycle and urban design components as highly important components of WSUD practice, with urban water infrastructure being rated slightly less highly. There were also six *not sure* responses for the infrastructure component. That said, the infrastructure component was, overall, rated as important.

Statistical analysis, using the Wilcoxon signed ranks test, indicated that the ratings for the infrastructure component differ from the ratings for the other components, at both the 5% and 1% levels of significance. There were no significant differences between the ratings for the urban stormwater management, urban water cycle and urban design components. The evidence from the survey indicates that all the components of WSUD practice are important, with the infrastructure component being ranked of slightly lesser importance than the others.

The survey participants confirmed that, to them, the components of WSUD practice identified in this investigation are all important, notwithstanding the infrastructure component being ranked less highly than the others. If the survey had shown very large differences in the importance of the components, or had identified some components as relatively unimportant, then the components of WSUD practice identified in this investigation would need to be re-evaluated. This situation did not arise.

4. Conclusions and recommendations

The survey indicates that statutory land use planning does favourably influence the implementation of WSUD practices, by making their adoption a legally-binding requirement.

According to the participants, statutory land use planning tools, which include specific quantitative targets, more strongly encourage the adoption of WSUD practices, compared with controls lacking them. These findings are consistent with previous reports that specific, quantitative targets are essential elements of the regulatory framework for WSUD (Taylor and Weber 2004; Mouritz and Shepherd 2006; Potter and RossRakesh 2007). The survey did not support the view that a less prescriptive approach should be used, to encourage flexibility and the ability to consider local circumstances (Lloyd 2001).

While the survey did indicate that statutory land use planning encourages the adoption of WSUD practices, it also identified factors that limit the influence of current planning frameworks. One limitation was that statutory land use planning provides less encouragement at infill sites, compared with greenfield sites. With state governments having set targets for infill development for Australia's major cities, which range from around 50 percent of total urban development to 70 percent (Newton et al. 2012, 482), identifying ways to encourage the adoption of WSUD practices at infill sites is important.

A further shortcoming of current statutory land use planning systems was identified, associated with the influence of these systems on different components of WSUD practice. The survey indicated that statutory land use planning mainly focuses on, and encourages the adoption of, urban stormwater management practices, and has significantly less influence on the other components.

This investigation suggests that reforms of statutory land use planning systems, to better encourage the adoption of WSUD practices, should consider:

1. Potential changes to statutory land use planning systems, to ensure that controls for infill development include WSUD requirements similar to those applicable to greenfield development. In situations where such changes to statutory land use planning are not feasible, the use of, for example, building regulation to encourage the adoption of WSUD practices in infill developments could be considered.
2. Including requirements relating to the urban cycle as a whole and its links with the urban design process in statutory land use planning tools, such as state level planning provisions, structure plans and development approvals. This could be accomplished by including requirements, such as specific mandatory targets, that relate to the components of WSUD practice identified in this study, in planning tools.

The idea of developing specific targets for the components of WSUD practice identified in this investigation does warrant some discussion. The inclusion of specific quantitative targets for urban stormwater management in statutory land use planning tools, such as Clause 56.07 of the Victoria Planning Provisions, is well established and has been reported to improve stormwater management practices (Potter and RossRakesh 2007). There are also examples of quantitative targets being identified for the urban water cycle and included in statutory land use planning tools, such as a potable water substitution target that was included in a precinct structure plan in Melbourne (Corbett 2012, 2959).

However, there appears to be a lack of targets related to the urban water infrastructure component of WSUD practice, which would encourage the use of a combination of centralised and decentralised infrastructure, in current statutory land use planning tools. The absence of targets for this component is of concern. The precedent provided by urban stormwater management targets suggests that, ideally, urban water infrastructure targets would be described numerically, in a form that could be incorporated in planning tools.

The process of setting targets for the urban design component, which could be included in statutory land use planning, would differ from that used for the other components. The urban stormwater, urban water cycle and urban water infrastructure components relate to tangible physical elements. This suggests that, in principle, quantitative targets can be set for these components, and, further, that the compliance of urban developments with such targets could be assessed by technical modelling software. However, 'urban design' is a more elusive concept, which appears to be more difficult to describe in simple physical terms, or modelled with engineering software. This suggest that a different approach to defining objectives, and assessing the compliance of proposed developments with such objectives, is required for this component of WSUD practice. A possible approach could be to identify examples of sound urban design outcomes, in a range of development contexts, and codify such outcomes in guidelines or codes of practices. The guidelines or codes could then be referenced by statutory land use planning tools.

The identification of appropriate requirements for <u>all</u> components of WSUD practice, which could be included in Australian statutory land use planning systems, should be a priority. This would ensure that statutory land use planning meets the challenge of encouraging the adoption of WSUD as a broad concept that extends beyond stormwater management, to include all the components of WSUD practice identified in this paper.

5. ACKNOWLEDGMENTS

I would like to acknowledge the support of the Commonwealth of Australia, through the Cooperative Research Centre Programme. My supervisors, Professor Graeme Hodge and Dr Colin Campbell, have provided essential direction, support and encouragement. I would not have been able to carry out the survey without the generous assistance and support of Fiona Chandler and Steve Pogonowski from the CRCWSC. Lachlan Macquarie from Monash University provided invaluable advice about the statistical analysis of the survey results. I would also like to thank my colleagues at the CRCWSC for their support and encouragement, and critical insights.

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