The potential of local planning instruments to unlock blue-green solutions for decentralised stormwater management

Driving practice towards a Water Sensitive City

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The potential of local planning instruments to unlock blue-green solutions for decentralised stormwater management.

Driving practice towards a Water Sensitive City

by Emily Salvisberg

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The potential of local planning instruments to unlock blue-green solutions for decentralised stormwater management

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Abstract

Blue - Green (BG) Infrastructure provides a promising solution to create water sensitive cities in the future. This decentralised stormwater management approach mimics nature and delivers multiple benefits for the urban environment, including resilience to climate change effects, stormwater quality as well as urban greening and cooling. Despite known benefits, the uptake of the approach is slow. This thesis investigates the influence of local planning instruments in realising BG Infrastructure in Melbourne, Australia. This city is recognised as a pioneer in Water Sensitive Urban Design (WSUD). Interviews and an online questionnaire with local WSUD practitioners seek to identify influential factors and their role in driving or creating barriers for the approach in local government planning. The results suggest a need for efforts that strengthen institutional and environmental aspects, to ensure that BG Infrastructure is not only physically realised, but also designed optimally, so that ecosystems are protected and measures function over the long term.

Key Words

Blue – Green Infrastructure; Decentralised Stormwater Management; Local Planning Instruments; Water Sensitive Urban Design; Water Sensitive Cities

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Acronyms

BG Infrastructure: Blue- Green Infrastructure

BMP: Best Management Practice

BPEM: Victorian Stormwater Committee's *Urban Stormwater Best Practice Environmental Management Guidelines* (1999)

BPP: Best Planning Practice

CoM: City of Melbourne

CoPP: City of Port Phillip

CRC: Cooperative Research Centre

DELWP: Victorian Department of Environment, Land, Water and Planning

GI: Green Infrastructure

IPCC: International Panel on Climate Change

IUWM: Integrated Urban Water Management

IWA: International Water Association

IWM: Integrated Water Management

LID: Low Impact Development

LIUDD: Low Impact Urban Design and Development

MLP: Multi-Level Perspective – Transition Theory

SCM: Stormwater Control Measures

SUDS: Sustainable Urban Drainage Systems

SUWM: Sustainable Urban Water Management

TIS: Technical Innovation Systems – Transition Theory

TM: Transition Management

UWM: Urban Water Management

VPP: Victorian Planning Provisions

WSC: Water Sensitive City

WSUD: Water Sensitive Urban Design

1. Planning for Stormwater in Cities

Stormwater management in dense urban areas is facing new challenges due to urbanisation and population growth, aging drainage infrastructure and uncertainties from the unpredictability of climate change. Traditional water management approaches in dense areas have relied on centralised systems, however these systems are not well suited to manage the complexity of water challenges (Brown, Rogers, & Werbeloff, 2018; Nelson, 2012).

This chapter outlines the challenges experienced by existing stormwater management in cities and promotes Blue - Green (BG) Infrastructure as the preferred approach for delivering a nature-based system with multiple benefits. Despite the extensive knowledge of academics and practitioners about the benefits of BG Infrastructure, the transition to this approach is slow. The slow transition is central to the research problem that this thesis seeks to address, drawing on Melbourne's experience to highlight barriers, drivers and implications for local planning instruments.

1.1. Urban Stormwater Management Challenges

Stormwater is a precious resource for urban areas, recharging ground water and surface water bodies, which are used as the source for potable water supply in cities. However, stormwater systems are facing several challenges for its management due to urban densification with increasing impervious areas, climate variability and capacity limitations of conventional systems.

1.1.1. Urban Densification of Cities

In 2018, more than half of the world's population were living in urban areas, which is expected to rise to 68% by 2050 (United Nations, 2018). The International Water Association (Skinner, 2012) identifies the key role that water management plays in future cities, to ensure that urban places are liveable, productive and sustainable. Especially with the continued demand for water, calculated as having tripled over the last 50 years, with an estimate that globally there will be a 40% supply shortage of water by 2030 (Koop & van Leeuwen, 2017). Increasing urbanisation places significant pressure on the availability of potable water supply, but also the need for stormwater drainage (Larsen, Hoffmann, Lüthi, Truffer, & Maurer, 2016).

The growth of urban areas is closely related to sustainable development in its economic, social and environmental dimensions (United Nations, 2018). The densification of cities is driven by urban planning strategies that seek to deliver additional floor space in areas served by existing infrastructure and networks (Newton, 2018). Existing urban areas are identified to provide an attractive location to boost housing supply for the synergies provided in those locations - and in many cities, an undersupply of housing and its delivery remains an ongoing challenge (Newton, 2018). However, in the delivery of housing supply, neoliberalism leadership often prioritises efficient delivery over climate adaptation and innovation opportunities (Moloney, Bosomworth, & Coffey, 2018). This pressured development agenda limits the inclusion of innovative stormwater measures in dense urban areas (Newton, 2018).

The specific challenge of urban densification for stormwater is widespread sealed, impermeable surface cover, which can include a surface coverage of up to 90% which negatively impacts the natural water cycle (Hoyer et. al, 2011). A study by Walsh et. al (2012) investigates ecological responses to different stormwater drainage systems. Their findings highlight that urban stormwater runoff from impervious surfaces during and immediately after precipitation events, has the largest impact on urban streams and rivers, with a higher percentage of pollutants, its altered increased volume, pattern and quality of flow resulting in degradation and ecological damage (Walsh, Fletcher, & Burns, 2012). Under normal conditions, water flows in a cycle of precipitation, infiltration, surface runoff and evaporation, however the hard sealing of surfaces disturbs this natural hydrological course (Arnold & Gibbons, 1996). Surface sealing reduces the ability of precipitation to collect and infiltrate with natural nutrients and recharge groundwater and other receiving surface water bodies, which impacts available drinking water for cities (Arnold & Gibbons, 1996; Nelson, 2012). As a result, the micro-climate of urban areas is also impacted, as the removal of pooled water reduces opportunities for natural cooling through evaporation (Hoyer, Dickhaut, Kronawitter, & Weber, 2011; Nelson, 2012).

1.1.2. Changing Climatic Conditions

International reports, such as those released by the Intergovernmental Panel on Climate Change (IPCC), have heightened awareness of damaging effects from climate change. Effects anticipated include projected 1.5°C - 2°C temperature increases, as well as uncertain variability of climate and weather-related events in the short and long term. Policy-makers are advocated to prepare for the greater variability and extremes to be experienced by urban areas, which in a non-linear character will be damaging for other life support systems (IPCC, 2018; Peter & Swilling, 2012).

Weather extremes as a result of a changing climate make urban areas particularly vulnerable. Severe storms, flood events and high temperatures, add to already warm temperatures experienced from the urban heat island effect (IPCC, 2018). Changing patterns of precipitation will have significant implications for flood risk, droughts and availability of water supplies, water quality, and sewer overflows. A higher frequency of flash floods, with damage to property, as well as risk to human life is also anticipated (IPCC, 2018; Nelson, 2012).

1.1.3. Capacity Limitations of Existing Urban Water Management

The limitations of conventional stormwater infrastructure systems in coping with current water demands are widely known (Hering et al., 2012; Larsen et al., 2016; Walsh et al., 2012). Conventional systems are often referred to as urban water management (UWM), which is characterised by a centralised approach whereby stormwater is rapidly drained from urban areas. The collection system is either combined in one pipe with wastewater, or drained away in a separate pipe network, treated in a centralised wastewater treatment plant and then released into receiving water bodies (Hoyer et al., 2011; Nelson, 2012). However, the combination of wastewater and stormwater increases the occurrence of sewer overflows and release of micro-pollutants to receiving rivers during heavy storm events. Further, the rapid drainage of stormwater devalues its role and nutrient resource in the natural water cycle (Arnold & Gibbons, 1996; Hoyer et al., 2011).

Although UWM systems, since their establishment in the early 20th century, are efficient in delivering main services securely, at a good quality to many customers, and in an organised way through institutional planning (Nelson, 2012), Larsen et. al (2016) argue that the system is weakened by its strong dependency on large quantities of water, long planning horizons and a need for stable institutions. They recognise that conventional systems are also incurring increasing economic, social and environmental costs, even for countries that have a long tradition of successful practices. Future challenges of water management in a changing climate, particularly the variability of stormwater events, expose the limitations of the UWM systems, and identifies the need for a more widescale approach to adaptation.

1.2. Urban Adaptation

The design of the built environment has an important role in the management of stormwater, in its influence on how water transverses surfaces to receiving water bodies. Planning of urban areas to address stormwater management today is critical in the lifetime of structures, so that they are adaptive to challenges in the future. Stormwater quality and resource management efforts can operate at different scales including a whole of catchment perspective, neighbourhood level as well as building level. They integrate water, open spaces and built form. Adaption measures within these different scales also range in approach from implementing simple structural solutions to monitoring nutrients, peak flows and strategies, to more complex governance and community engagement measures (IPCC, 2018; Shaw et al., 2007; Skinner, 2012).

Local governments with their responsibility for spatial planning and management of local drainage infrastructure are well placed to improve current stormwater practices. Stormwater management design early in the planning process is important so that it can be integrated into the urban environment (Morrissey et al., 2018; OECD, 2011). Planning instruments are the tools that guide built form outcomes encompassing reduction of impervious surfaces to designating space for optimal stormwater treatment before its release to water bodies.

Planning instruments can be formal and informal. A study of planning instruments in OECD countries has identified two broad typologies of formal planning instruments (Silva & Acheampong, 2015) as (i) development plans which spatially coordinate development (e.g. strategic and master plans) and (ii) development management instruments which control, regulate and encourage desired outcomes (e.g. zoning plans). Informal instruments do not have regulatory implications but are important for education and information (Carmona, 2017).

Despite increasing industry support for the use of planning instruments to manage stormwater, traditionally an engineering responsibility (Victorian Stormwater Committee, 1999), they experience a number of challenges. Recent studies criticise planning instruments for their lack of detailed consideration and improvement of ecosystem services reflecting the earlier paradigm that stormwater is wastewater (Kuller, Bach, Ramirez-Lovering, & Deletic, 2017). Also their complexity and lack of coherent integration across municipal departments (Morrissey et al., 2018). These criticisms question how influential planning instruments are in managing urban stormwater at municipal level.

1.2.1. Decentralised Stormwater Management

Built environment interventions for stormwater management have gained international attention over the past few decades towards addressing UWM limitations (Brown et al., 2018; Larsen et al., 2016). Water strategy reforms have

co-evolved with society's growing concerns over community wellbeing, community health and sustainable development, recognising the vulnerability of the natural environment as a result of human activities, and the need to address these issues (Marlow, Moglia, Cook, & Beale, 2013).

This has led to practices in the built environment, especially at the municipality level, that address the management of the urban water cycle using a decentralised approach. In contrast with centralised systems, decentralised water management emphasises sustainable services by mimicking natural processes (Brown et al., 2018; Marlow et al., 2013). Many terms are used in literature to refer to the overarching paradigm of decentralised water systems such as sustainable urban water management (SUWM) and Blue - Green Infrastructure, among others.

Blue - Green (BG) Infrastructure refers to 'blue' assets as water-based features and 'green' assets which are distinguished as trees, parks and gardens (Rydin, 2010). These decentralised systems mimic nature to control pollution and ecological disturbances. They reduce impervious surfaces to maintain the natural flow volume and quality of stormwater to water bodies (Marlow et al., 2013). This also provides opportunities for recreation and improved urban amenity through an increase of green landscaping.

WSUD is a concept that delivers BG Infrastructure and is used widely among practitioners in the Australian context, which first entered stormwater management discussions in the 1990s. Fletcher et al. (2015) provides a chronology of the term, identifying that its early application was for stormwater management by drainage practitioners. This was then followed by position papers that described WSUD as being more closely relevant to urban planning and design, through minimising hydrological impacts of urban development on the surrounding environment (Lloyd, Wong, & Chesterfield, 2002, p2).

1.3. Water Sensitive Cities

The International Water Association (IWA) (2012) recognises that sustainable cities of the future will need to have in-built resilience to shocks which needs to be planned and designed from the outset, so that the city itself is 'water sensitive'. They identify water having a critical role in 'Cities of the Future' which are defined as being (Nelson, 2012, p(ii)):

- *Liveable Cities – by delivering safe, fit-for-purpose water supplies; attractive urban landscapes that support healthy communities and improved flood protection';*
- *Sustainable Cities – by ensuring smaller environmental footprints; healthier waterways and parklands; landscapes that are resilient to natural disasters and climate variability;*
- *Productive Cities – by providing water security for the future; affordable water services; a clear, transparent and contestable investment climate; and economic prosperity*.

To achieve cities of the future the IWA propose 12 principles to progress the water sensitive agenda. This recognises among many others, the importance of effective water governance and balancing BG Infrastructure approaches in high density locations (Skinner, 2012).

In an Australian setting, a growing body of work has emerged to support development of a Water Sensitive City (WSC) (Wong & Brown, 2009). Water quality management issues and a drought lasting from 1996 to 2010 known as the Millennium Drought, raised the agenda of sustainable stormwater management in a significant way at national, state and local government levels (Brown & Clarke, 2007). The concept of the WSC is a stated goal of the Australian Commonwealth's National Water Initiative under Clause 92, which calls for innovation and capacity building for water sensitive Australian cities, and has resulted in the development of national water quality guidelines for the harvesting and use of urban stormwater and for evaluating WSUD options (National Water Commission, 2011).

The WSC is a vision that recognises the role of water in creating connected, vibrant and liveable communities, and pushes for an overhaul of socio-technical processes and a change in existing attitudes towards water management (Brown et al., 2018; Wong & Brown, 2009). In literature, three key pillars are promoted to underpin its development, including (i) access to a diversity of water sources underpinned by a diversity of centralised and decentralised infrastructure, (ii) provision of ecosystem services for the built and natural environment, and (iii) socio-political

capital for sustainability and water sensitive behaviours (Wong & Brown, 2009, p673).

Melbourne, Australia, is a recognised leader in its application of WSUD measures having achieved milestones in its transition from a conventional stormwater drainage system towards sustainable urban water management (Brown & Clarke, 2007; Brown et al., 2018). The shift began in the early 1960s and has placed Melbourne ahead of other Australia cities, by its mandates and schemes, and its active engagement of municipalities as well as private landholders in stormwater treatment development projects (Wong & Brown, 2009). A longitudinal study on the development of WSUD in Melbourne (Brown & Clarke, 2007) identifies that early WSUD pilot projects were influential in showcasing the possibilities of this approach to the development sector. However, these pilots often relied on heavy government investment to ensure their viability. The transition phases toward widespread acceptance and practice of WSUD in Melbourne however, happened incrementally.

Brown et al. (2009) developed an Urban Water Transitions Framework to describe the transition process from a centralised stormwater management system to an integrated urban water cycle management system (i.e. stormwater, wastewater and potable water). The Framework explains that a city needs to transition between states of water management such as (Brown et al., 2018):

- *Drained City:* conventional UWM practices that drain stormwater into a centralised system.
- *Waterways City:* greater value of social, environmental and aesthetics of clean waterways and investment is made to improve stormwater management.
- *Water Cycle City*: active conservation, recycling and regeneration of water and other resources, such as energy and nutrients from stormwater.
- *Water Sensitive City (WSC):* communities actively protect natural resources, providing resilience to climate change, and adopt infrastructure and technology that is flexible and evolving.

Between these states, differing 'hydro-social contracts' emerge (Lundqvist, Turton, & Narain, 2001). This is a term used to describe the values and implicit agreements on how water should be managed, expressed through governance arrangements. Brown et al. (2009) propose that the hydro-social contract in a WSC is one that is adaptive and flexible to co-exist with diverse infrastructure, which is a considerable overhaul of conventional governance approaches (Wong & Brown, 2009). Figure 1.1 illustrates the urban Water Transition Framework.

Brown et al. (2018) identify Melbourne as being within the Waterways City state, as a result of its widespread practice of WSUD, extensive policy and regulatory frameworks, and a network of actors championing this work in policy and practice. They regard Melbourne as having a strong foundation to transition rapidly towards the WSC vision. Figure 1.2 illustrates how a transition would take place in the regime of a centralised stormwater system. The process begins with a predevelopment stage comprising the emergence and definition of an issue, a shared understanding of the issue and knowledge dissemination. Followed by a take-off to acceleration phase, with policy and practice diffusion, and finally a phase of stabilisation with the embedding of a new practice. This development curve is explored by sustainable transition studies that observe socio-technical innovations from their inception to dispersion within high income countries.

Also interesting to observe, is the concept of leapfrogging, and whether this has any relevance for the Melbourne study case. Leapfrogging is more commonly used for newly industrialising countries that learn from mistakes of other countries and directly implement more sustainable systems of production and consumption, leaping ahead of existing industries and becoming a technological leader (Binz, Truffer, Li, Shi, & Lu, 2012). It poses the question whether Melbourne could leap ahead, learning from lessons about the WSC vision.

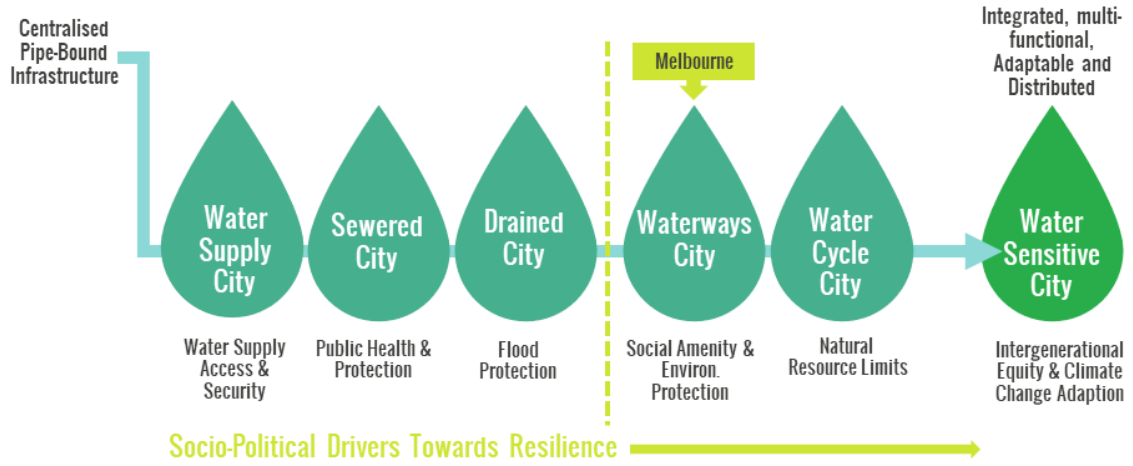

Figure 1.1: Urban Water Transition Framework. Image adapted from Figure 8.1 in 2 in 'Urban Sustainability Transitions: Australian Cases- International Perspectives' Chapter 8 'A Framework to Guide Transitions to Water Sensitive Cities' by Brown et al., 2011, p.133

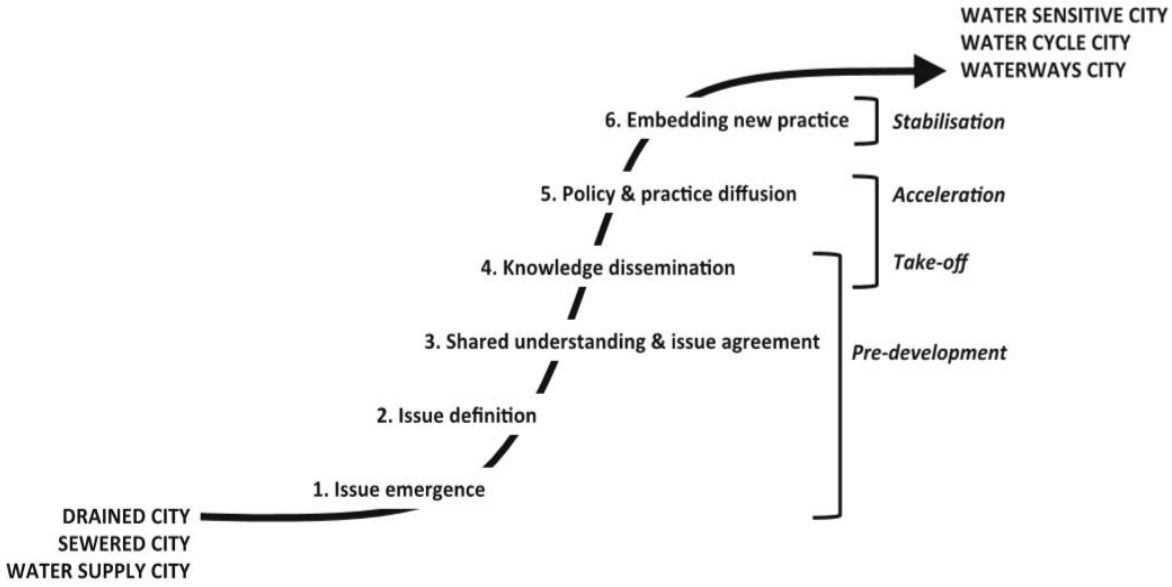

Figure 1.2: Six Phases in the Transition Towards Water Sensitivity. Image Figure 8.2 in 'Urban Sustainability Transitions: Australian Cases- International Perspectives' Chapter 8 'A Framework to Guide Transitions to Water Sensitive Cities' by Brown et al., 2018

1.3.1. Impediments to Change

Despite known benefits of BG Infrastructure, the adoption of the approach is much slower than investments in conventional approaches (Brown et al., 2018). Impediments to change have been popularly attributed to institutional 'lock in' effects as a result of the dominating infrastructure regime of centralised UWM, its economy of scale and shared adoption (Foxon et al., 2002). Other studies highlight the lack of expertise in the design of systems to account for unique site conditions, and that there is a need for 'Best Planning Practice' to account for site specific criteria (Kuller et al., 2017).

Marlow et al. (2013) relates the transition challenge to conceptual weaknesses of BG Infrastructure, that need to be further addressed, based around four issues:

- *Difficulties in predicting the system effects of innovative solutions.* As BG Infrastructure is innovative compared to the prevailing system, there is lack of institutional capacity and governance arrangements to manage new system performance, impacts, uncertainties and risk, such as new maintenance requirements for rainwater tanks.
- *Practical challenges in managing innovations in technologies and service provision strategies.* BG Infrastructure adoption can meet community resistance to change, diffuse management responsibilities and new skill requirements.
- *Financial considerations.* The price competitiveness of BG Infrastructure and the communities' willingness to pay for ecosystem services is not transparent. As the community pay charges related to the centralised water infrastructure, their knowledge of externalities and benefits is limited.
- *Effect of bias and advocacy of technology and management paradigms.* Conflicts occur between prevailing interests and bias of preferred management approaches, where technical issues can be understated and solutions are over-stated by proponents of BG Infrastructure. For example, centralised infrastructure due to its legacy, life span and extent needs to undergo a gradual transition to incorporate BG Infrastructure.

1.4. Problem Statement

Conventional centralised UWM is limited in addressing future stormwater challenges faced by dense urban areas. BG Infrastructure provides a promising solution for cities to adapt and be reflexive to the variability of a changing climate and increased stormwater runoff volumes from growing impervious surfaces. Their provision of cost-effective solutions with multiple benefits for ecosystem services, water provision as well as public health will play an important role in progressing the agenda of the WSC for Melbourne, but also for other dense urban areas.

Additional pressure on aging and limited UWM networks as a result of increasing urban infill development should be an impetus for change in more widescale adoption of BG Infrastructure throughout cities. Although well recognised as an approach the transition to BG Infrastructure is slow. Different factors can either impede BG Infrastructure as a barrier, and others can drive adoption. The prevailing regime and legacy of centralised UWM is an example of a barrier, as BG Infrastructure is a novel approach which tests institutional capacity to cope with unknown risks for its resources and management.

Different local planning instruments are available to manage stormwater in the urban environment, and can guide, suggest and enforce the implementation of BG Infrastructure. However, the level of influence that the different planning instruments have in the outcome of BG Infrastructure is questionable. Studies criticise planning instruments for their complexity, incoherency and a lack of guidance for ecosystem services, which provides an opportunity to better understand the influence of planning instruments to overcome their challenges and leverage solutions for BG Infrastructure.

This thesis seeks to address the research problem by investigating how influential local planning instruments are in the delivery of BG Infrastructure in Melbourne, Australia as a dense urban study case.

1.5. Thesis Structure

This introductory chapter provided an overview on the challenges for stormwater management in dense urban areas, how BG Infrastructure as an approach can assist the WSC transition and impediments BG Infrastructure encounters as a novel approach.

Chapter 2 reviews literature that has informed this study, encompassing climate adaptations and sustainability transitions, urban water governance and planning, a more detailed insight about BG Infrastructure and the introduction of this thesis's conceptual framework on factors that are barriers and drivers in the realisation of BG Infrastructure. Research questions are also outlined.

Chapter 3 details the methodology undertaken to address the research aim using two qualitative case studies to identify the influence of local planning instruments, and persisting barriers and drivers experienced in realising WSUD in Melbourne, Australia. The mixed methods approach used for the case studies involved a document review, field trip, and semi-structured interviews with WSUD practitioners. An online questionnaire was undertaken with a larger number of WSUD practitioners across Greater Melbourne to validate interview responses.

Chapter 4 introduces the Melbourne case study projects guided by the Multi-Level Perspective and Technological Innovation System transition theory framework. This framework describes Melbourne's stormwater landscape as a system, influenced by different factors impacting upon the progression of WSUD to becoming a mainstream practice.

Chapter 5 presents the results of the WSUD practitioner interviews and online questionnaire responses. Persistent barriers, drivers and influence of local planning instruments are discussed.

Chapter 6 concludes the study outlining key findings, with final remarks on recommendations and study limitations and opportunities for future research.

2. Barriers and Drivers – A Review of Literature

This chapter introduces the key literature framework which has informed the methodology for this thesis, addressing the topics of climate adaptation and sustainability transitions, water governance and a conceptual framework of barriers and drivers experienced by Blue-Green (BG) Infrastructure. Key knowledge gaps are highlighted and research questions are defined.

2.1. Climate Adaptation and Sustainability Transitions

2.1.1. Climate Adaptation Governance

International awareness on the causes and effects of climate change has translated into adaptation measures to reduce damaging effects of climate events. These measures are underpinned by governance, that is, institutional arrangements. More recent development in adaption governance seeks to build resilient institutions and social networks, by increasing the capacity of people to deal with uncertainty (Quay, 2010). It can be described as a practice that addresses uncertainty through hypothesis testing, monitoring and evaluating (R. Foxon, Reed, & Stringer, 2009), including community co-management (Plummer, 2009). It is also anticipatory in that it uses scenario frameworks which are updated when new information becomes available (Quay, 2010).

Legitimacy is the key issue in mainstreaming climate adaptation in policy, which is perceived as uncertain, controversial and complex (van Buuren, Driessen, Teisman, & van Rijswick, 2013). Successful implementation of adaptation policy is problematic, as there exist different perspectives on legitimacy from legal, planning and network perspectives, which are not easily compatible (Fröhlich & Knieling, 2013). The growth in this policy domain raises new challenges in coping with many possible impacts, hazards, stakeholders and policy areas involved (Koop & van Leeuwen, 2017; van Buuren et al., 2013). Hazards associated with a changing climate creates demand for proactive adaptation processes (Hurlbert & Gupta, 2019; Koop & van Leeuwen, 2017), as well as scientific knowledge and policy on how measures can be implemented successfully (Fröhlich & Knieling, 2013).

Hackmann & St Clair (2012) in their advocacy for further research argue that social science knowledge is needed to understand what pathways are available for influencing decision making. Koop & van Leeuwen (2017) identify that in the new development of adaptation policy its often the occurrence of natural hazards that lead to major policy changes, such as drought or flooding which quickly raise awareness of problems. However reactive policy is often ad hoc, ineffective and expensive, and so it is argued that measures should instead be proactive (Hackmann & St Clair, 2012; Hurlbert & Gupta, 2019). As cities are large contributors as well as equally vulnerable to the impacts of climate change, urban areas should be supported by an integrated long-term plan, which has bold, reflexive and time pressing actions for adaptation (Hackmann & St Clair, 2012; Koop & van Leeuwen, 2017; van Buuren et al., 2013).

2.1.2. Sustainability Transitions

Sustainable transitions involve the observation of fundamental changes in systems which are helpful to understand the emergence of new processes and paradigms (Loorbach, 2010). There is growing international literature on sustainability transitions which are salient in the address of climate change impacts through the innovation and application of new technologies and processes (Markard, Raven, & Truffer, 2012; Moloney et al., 2018). Transition analysis often uses governance as a tool to review change in systems that can steer current practices in a new direction. Sustainability transitions are characterised by a shift to more sustainable means of production and consumption (Kuller et al., 2017).

There are several frameworks to observe transitions which have developed independent of each other. Despite this, the frameworks share a system thinking with multiple networks of actors, influenced by institutions and culture, involve mutual interactions within a system (co-evolution), they recognise that routine behaviour avoids risk (path dependency and 'lock-in') and knowledge is recognised as an important resource, and learning process (Twomey & Gazulusoy, 2014). Two key frameworks are Multi-Level Perspective (a subset of socio-technical transitions) and Technological Innovation Systems (a subset of innovation systems). The second framework is promoted for its integration of socio-technical transitions with innovation systems through its study of emerging novel technologies (Markard & Truffer, 2008).

Multi-Level Perspective (MLP)

Social-technical transition frameworks is an umbrella term that includes the Multi-Level Perspective (MLP) framework (Twomey & Gazulusoy, 2014). Socio-technical systems comprise networks of actors (i.e. individuals and organisations), institutions (i.e. societal and technical norms, regulations and standards of good practice) as well as materials and knowledge – all of which are interrelated and dependent (Markard et al., 2012; Morrissey et al., 2018). Transitions are focused on how societal

systems (e.g. stormwater management) fulfil society's needs, which is referred to as functioning, and are argued to be different from normal societal change as the change occurs in a sequence of patterns (de Haan & Rotmans, 2011), which occur under conditions referred to as drivers, including:

- *Stress:* when the existing system is inadequate or inconsistent in its ability to provide the dominant way societal needs are met.
- *Pressure:* developed from alternative technologies that become viable competitors to the existing system.
- *Tension:* when the structural aspects (e.g. infrastructure, economic and legal) of the system compromise environmental or cultural aspects (e.g. environmental pollution and public awareness).

The MLP framework explores the dynamic between three constellations at different levels (i.e. macro, meso and micro) which place pressure on the existing system for new opportunities and changes (de Haan & Rotmans, 2011; Markard et al., 2012). These are illustrated in Figure 2.1 and are outlined.

Landscape level (macro)

This level is the wider societal system and encompasses cultural patterns, the economy, legal structures, political developments and the natural environment (Twomey & Gazulusoy, 2014; Wihlborg, Sörenson, & Olsson, 2019). For stormwater management, the landscape can include climate, legislation and politics.

Regimes level (meso)

This is the most powerful and dominates the system, encompassing the structures that represent current practices and routines, including rules and technologies (Twomey & Gazulusoy, 2014) and are the dominant way societal needs are met (Wihlborg et al., 2019). For example, centralised systems for the management of stormwater.

Niches level (micro)

This level provides space for experimentation and innovation and has less structure and regulation (Loorbach & Rotmans, 2010). Niche systems represent the emergence of a new market or technology that is not controlled within an existing or prevailing regime. Through social learning and experimentation, with forerunners trialing ideas, niches can grow, stabilise and compete with existing regimes (Loorbach, 2010).

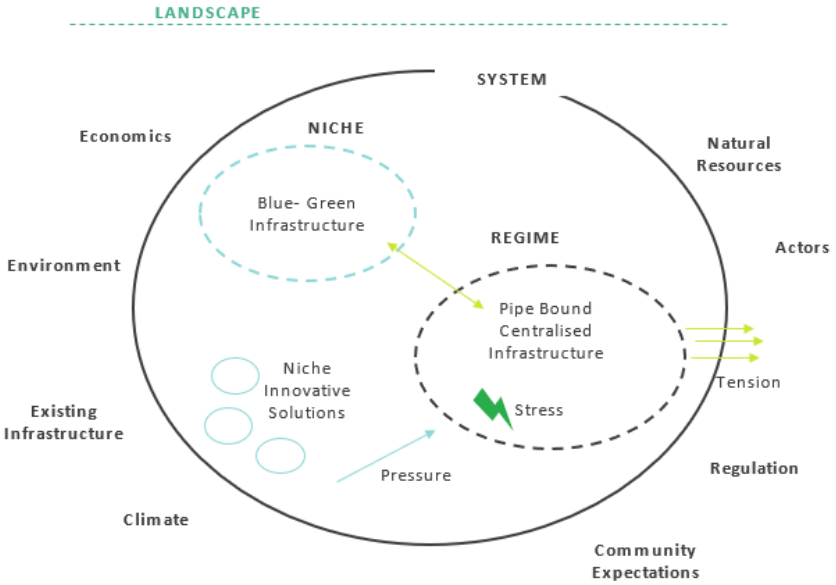

Figure 2.1: Multi-Level Perspective of socio-technical systems. Image adapted from Figure 1. In 'Assessment of barriers and drivers for implementation of blue-green solutions in Swedish municipalities' by Wihlborg et al, 2019 p707

Ways in which constellations rise to power are the building blocks of transition storytelling. They can be told as chain of patterns over time which makes them qualitatively comparable. Ways of rising to power include (de Haan & Rotmans, 2011):

- *Empowerment:* bottom-up emergence of a new niche, or an existing one gains power and becomes viable to the mainstream system. (e.g. recognition through community lobbying)
- *Reconstellation:* top-down pushing such as policy reform or new infrastructure implementation and is an abrupt change.
- *Adaption:* internally induced change where conditions within a main system prepare for a transition to better meet society's needs. Typical processes include reorienting to new market groups, reorganising structure and innovations through modernising.

Technical Innovation Systems (TIS)

TIS investigates the development, diffusion and utilisation of novel technologies (Markard et al., 2012).The key idea is that for a technological system to thrive, structural dimensions should interact successfully so that functions and activities are fulfilled (Twomey & Gazulusoy, 2014). To identify the different dimensions of the system, a classification has been developed which comprises (i) actors that include the society, private and public sector, academia etc., (ii) institutions that define laws and norms, (iii) interactions at the network or individual level, and (iv) infrastructure, knowledge and finance (Wieczorek & Hekkert, 2012). The approach has been commonly used to inform policy decision-making, through identifying barriers and drivers of market or technology failure (Markard et al., 2012; Twomey & Gazulusoy, 2014).

Despite the growing application of MLP and TIS frameworks in scholarly research to explain transitions, they have some drawbacks. For instance TIS has been criticised for giving little attention to the reasons behind system problems, (Lachman, 2013). The MLP framework has been criticised for giving little consideration to relationships between the roles of actors (Markard & Truffer, 2008). In response to these critics, further research of transitions is promoted to use a hybrid of complementary frameworks (Markard & Truffer, 2008) or altogether investigate transitions outside of these theoretical frames, to broadly observe spatial and institutional interactions (Hansen & Coenen, 2015; Markard et al., 2012).

2.2. Urban Water Governance and Planning

Urban water governance is critical in a sustainable development agenda, as the market is not focused on delivering environmental protection and social benefits (Rydin, 2010). The improvement in urban water governance is a prerequisite for achieving Sustainable Development Goal 6 for clean water and sanitation for all people (UNDP, 2019). Urban water governance can be defined as '…the political, social, economic and administrative systems in place that influence water's use and management', which determine the equity and efficiency in water resource service allocations, established through policies and institutions (UNDP Water Governance Facility, n.d.). Good practice water governance is identified as being underpinned by four dimensions (UNDP Water Governance Facility, n.d.):

- *Social:* equitable distribution amongst differing socio-economic groups;
- *Economic:* efficiency in water allocation and its role in overall economic growth;
- *Political:* equal rights and opportunities for water stakeholders to take part in legitimate decision-making processes; and
- *Environmental:* ecosystem functions.

Rogers & Hall (2003) recognise that international attention to good water management increased following the establishment of the 1992 Dublin Principles which classed water as an economic good. This recognition led to the development of universal principles for water management such as legitimacy, transparency and accountability (Rogers & Hall, 2003). However, despite awareness that good urban water governance is a key condition for a fairer and cleaner economy, the OECD's (2011) study on water governance in 17 OECD countries, reveals ongoing complex challenges due to multiplicity of actors, stakeholders and motivations.

The OECD (2011) study highlights obstacles for urban water governance at several levels, relating to information, capacity, policy, objectives, administration, funding and accountability. Across the countries studied, the most significant challenges identified were: (1)

institutional fragmentation, (2) ambiguous legislation, (3) poor implementation of multi-layered governance, (4) limited capacity at local level, (5) unclear allocation of roles and responsibilities, (6) fragmented financial management and (7) uncertain allocation of resources. Other issues included the lack of long-term strategic plans and insufficient resources to measure performance resulting in weak accountability and transparency (Koop & van Leeuwen, 2017). The role of institutions and frameworks in governance at all levels is a challenge and opportunity in progressing sustainable development (Bulkeley, 2006; Koop & van Leeuwen, 2017; van Buuren et al., 2013). Many scholars have investigated technological solutions, but far fewer have looked at institutional and governance aspects in building resilience in urban water governance (Rodina, 2018).

2.2.1. Local Authorities in Water Planning

Although water governance in many OECD countries occurs at multi-levels, (Koop & van Leeuwen, 2017; Rydin, 2010), local municipal governments are promoted as being well placed to progress change in water management (OECD, 2011; Pot, 2018; Rogers & Hall, 2003). A reason for their promotion relate to their role as pioneers initiating actions, as policy implementers and regulators, facilitators and managers (van der Vegt, Hoppe, & Stegmaier, 2015). They represent local interests to maintain public trust in government decisions and have detailed knowledge of local catchment conditions (Rogers & Hall, 2003). Representation of local interests relates to equity, an important component of good governance (Morrissey et al., 2018; Rydin, 2010). The OECD (2011) recommends that a top-down approach is not favoured, but instead a mixed approach to reflect and consider diverse stakeholder concerns at a local level.

Municipalities are confronted with future uncertainties about their ageing water infrastructure, which provides an opportunity to be progressive in establishing more resilient urban water management approaches supported by local policy (Pot, 2018). Cities play an important role in this respect, as they provide a space for experimentation and development of innovative ideas, which can test the existing regimes (Geels, 2013; Morrissey et al., 2018).

Water management design early in the planning process is important so that it can be integrated into the urban environment (Morrissey et al., 2018; OECD, 2011). Planning through governance is referred to as spatial planning which includes the coordination of land use, development activity and infrastructure investment (Rydin, 2010). How spatial planning interrelates with other modes of governance is important for progressing the sustainable development agenda (Koop & van Leeuwen, 2017; Rydin, 2010). This involves network governance in the sharing of social capital and learning amongst practitioners and the community (Morrissey et al., 2018; Rydin, 2010). Koop & Leeuwen (2017) suggest that successful transitions at a city scale can be driven by six processes:

- Developing a long-term shared vision;
- Incorporating stakeholder participation;
- Using SMART (i.e. specific, measurable, achievable, relevant and time-bound) transitions with a focus on co-benefits;
- Making data accessible and applicable; and
- Removing financial barriers; and
- Monitoring implementation.

2.2.2. Local Planning Instruments

Instruments used by actors and organisations to achieve outcomes are an important component of public policy (Carmona, 2017). There are several classifications of planning instruments which have a direct influence on built environment outcomes. Carmona (2017) draws upon lessons experienced by the UK government's advisor on architecture, urban design and public space to define planning instruments, illustrated in Figure 2.2. He defines **formal instruments** as being legally defined with regulatory responsibility. Formal tools are used to:

- Guide behaviour and outcomes (e.g. *design frameworks*) (Carmona, 2017).
- Incentivise through direct financial gain or trade-off, which act as a 'carrot' for good behaviour (i.e. *subsidy, direct investment,* process management and bonuses) (Carmona, 2017). These tools can be used to favour sustainable outcomes (Rydin, 2010; Silva & Acheampong, 2015). And are based on the assumption of costs and benefits in rational economic behaviour (Koop & van Leeuwen, 2017).
- Regulate/control by setting desired development standards (Rydin, 2010; Silva & Acheampong, 2015). Controls can be mandatory or discretionary in law and

policy (i.e. *developer contributions, adoption, development consent and warranting*) with sanction 'sticks' for non-compliance (Carmona, 2017). Monitoring and enforcement play an important role in the achievement of minimum standards (Rydin, 2010; Silva & Acheampong, 2015).

Informal or non-statutory instruments are used for education and information to internalise behaviour into decision-making, especially for complex problems like climate change (Australian Public Service Commission, 2009). Carmona (2017) classifies informal instruments according to their three functions:

- Assistance (i.e. *financial funding and enabling*);
- Evaluation (i.e. *indicators, design review, certification and competitions*);
- Knowledge (i.e. *practice guides, case studies, education and training); and evidence base (i.e. research and audits*).

Rydin (2010) classifies four tool types for the governing of sustainable urban development as information, collaborative action, incentives, and regulation. Information refers to communicative resources to influence actor's behaviours (Rydin, 2010) through for example, building rating schemes and best practice guides. Collaborative action represents facilitation and promotion of networks and partnerships, important in the building of consensus, social capital and monitoring of good practice and compliance of actors (Rydin, 2010). Information and collaborative action can be grouped together and referred to as personal relations (DDV, 2011).

Within the instrument framework, outlined above, a study of planning instruments in OECD countries has identified two broad typologies of planning policy instruments (Silva & Acheampong, 2015):

- *Development plans* which spatially coordinate development and consider social, economic and environmental issues, such as strategic and master plans.
- *Development management instruments* which control, regulate and encourage desired outcomes, such as zoning plans to specify allowed land use activities.

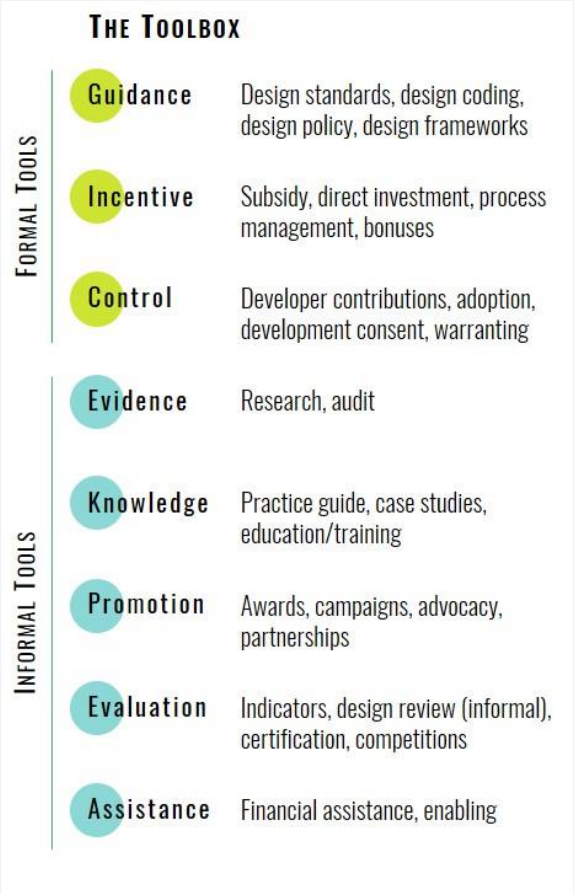

Figure 2.2: The Complete Design Governance Toolbox (formal and informal). Image adapted from Figure 16 'The formal and informal tools of design governance' by Carmona, 2017, p.31.

Silva & Acheampong (2015) argue that environmental objectives are best achieved by combining regulatory and incentive-based instruments where revenues raised can offset and be invested into environmental protection efforts. Despite more recent inclusion of sustainability concepts in policy documents and strategic plans, measures are criticised as elusive, ad hoc and small-scale (Morrissey et al., 2018). For example, policy documents have vision statements about sustainability, but there is a lack of measurable standards to implement the vision. This critique provides an opportunity to address limitations in new planning instruments. Table 2.1 provides an overview of the governance instruments, identifying their potential to counter resistance in sustainability outcomes

Table 2-1: Potential of Governance Tools to Promote Sustainability Goals. Adapted from Table 4.3 Tools for governing in 'Governing for Sustainable Urban Development', by Rydin, 2019, p57.

	Classification	Build will to act	Build capacity to act	Counter resistance to change	Planning Instrument Examples
Informal (i.e. non-statutory)	Personal Relations (Information and Collaborative Action)	Change actor perception and create agenda through networks for action.	Show change is possible and release resources in networks.	Counter information to undermine legitimacy of resistance and soft sanctions.	Practice guides, case studies, education and training, research and audits.
	Incentives	Provide an incentive for action.	Provide financial resources for action.	Restructure available resources to reduce actor power.	Financial funding through subsidies and bonuses.
Formal	Regulation (incl. guidance and incentives)	Clarify expectations and potential benefits.	Establish a route to achieve outcomes.	Control through regulatory action.	Development plans (e.g. strategic and master plans) and development management instruments (e.g. zoning plans, developer contributions, mandatory development standards)

2.3. Blue- Green (BG) Infrastructure

A diverse range of concepts have been developed that underpin and describe BG Infrastructure, including, but not limited to: green infrastructure (GI); integrated urban water management (IUWM); low impact development (LID); low impact urban design and development (LIUDD); stormwater control measures (SCMs); sustainable urban drainage systems (SUDS); and water sensitive urban design (WSUD). Fletcher et al. (2015) recognise that these concepts are relevant to the local conditions and perspectives where they were developed, addressing nuances and applications of principles, and a uniform set of terminology would fail to recognise this. Despite the differences in terms, the systems have three benefits in common, in contrast to centralised systems (Marlow et al., 2013):

- Creating a more natural water cycle, through stormwater management that controls pollution, reduces ecological disturbance, enhances urban amenity and recreational value. Implementation involves reduced impervious surfaces to maintain natural flow quality, quantity and frequencies.
- Enhanced water security through local source diversification, by using water of different qualities to fit a specific purpose. As the quality of potable water is not required for all uses, alternative supplies such as harvested rainwater can alleviate demand on waterbodies.
- Resource efficiency which aligns with sustainability goals by reducing water and energy and recovering nutrients.

In addition to the benefits outlined above, the approach also provides landscaping for recreational opportunities (i.e. aesthetic and amenity), and increases permeable surfaces and evaporative cooling to mitigate the urban heat island effect (Wihlborg et al., 2019).

Although information of costs remains limited (Marlow et al., 2013), promoters of BG Infrastructure reported to have a high investment return for urban areas, which can be estimated through proxies. For example, in the City of Portland, an initiative involving green alleys, rainwater tanks, and tree plantings was estimated to be 3-6 times more effective in managing stormwater runoff per US $1,000 invested, than conventional UWM methods (Foster, Lowe, & Winkelman, 2011). Not only are BG Infrastructure identified as low-cost solutions, but also as a good way to improve public health of recreational waterways and reduce the costs of treating polluted runoff, municipal energy expenses, flooding risk and related flood damage (American Rivers, ASLA, ECONorthwest, & Water Environment Federation, 2012).

2.3.1. Water Sensitive Urban Design (WSUD)

As outlined in chapter 1, WSUD is a common concept in Australia for BG Infrastructure. More recent developments of the WSUD concept have been its extension to encompass all aspects of integrated water cycle management (Mouritz, Evangelisti, & McAlister, 2006), and in Australia today, WSUD as the process, is now often used in parallel with the term Water Sensitive Cities, which is the end objective (Fletcher et al., 2015). Lloyd et al. (2002) in their industry report distinguish a difference between WSUD objectives and the techniques used to meet them. They identify *Best Planning Practices* (BPPS) as the process to follow in selecting locations for WSUD for optimal conditions for the functioning of ecosystem services. The site selection process involves:

- Undertaking a site analysis to audit regional land-use zoning, climate and landscape characteristics;
- Undertaking a land capability assessment to match physical landscape features to sustainable future land-uses once the site is fully developed; and
- Developing a land-use plan, which considers the layout, scale and arrangement of amenities, which provide greatest benefit to the downstream environment and the selection of WSUD techniques.

Ecosystem services relate to the capacity of natural systems to provide goods and services for humans needs (de Groot, Wilson, & Boumans, 2002). They include regulation of essential ecological processes and provision of habitat. The protection and optimum functioning of ecosystem services is therefore a critical consideration in WSUD design. Studies have investigated how the arrangement of the urban environment impacts upon ecosystems and argue that best practice always consider ecological systems beyond the physical boundaries of cities (Alberti, 1999; Kuller et al., 2017).

However, the design of natural systems is complex and unpredictable. Careful consideration is required for flexible conditions, which was explored in a study by Alberti (1999). The study observed the interrelationship of ecosystem landscapes and urban areas, in terms of form, density, grain, and connectivity of urban areas with four ecosystem dimensions of environmental performance including sources, sinks, ecological support systems, and impacts on human well-being. These dimensions were further observed with four properties of ecological systems to determine how they respond to change, including (Holling, 1978):

1. Selective connections: how ecological systems are selectively connected which has measurement implications;
2. Spatial heterogeneity: how events do not consistently occur over space and have different intensities.
3. Resilience: behaviour shifts in ecosystems, which can lead to misinterpretation of environmental changes.
4. Dynamic variability: an inconsistent quality of ecosystems and their ability to self-monitor and self-correct.

The careful consideration of ecosystem functioning in WSUD design has a large part to play in the overall success of the measures (Browne, Burge, & Long, 2014). For example in a study about WSUD measures across a municipality, it was found that the conditions for plants were not conducive to their survival, which resulted in poor performance and failure of the raingardens.

Hoyer et al. (2011, p35) address the importance of pairing of WSUD measures with their physical location and land use to support optimum functioning. Otherwise disruption to the systems can occur with debris from busy roads, or placement can cause obstruction to walkways which may cause damage. They promote the consideration of five topics to assist the successful planning of WSUD in accordance with principles. The topics relate to

water sensitivity, aesthetics, functionality, usability, and public perception and acceptance. Principles relate to:

- bringing the water cycle closer to a natural cycle;
- integration with the surrounding area including local conditions and intended use;
- consideration of maintenance and possibilities for changing conditions;
- include multi-disciplinary teams and stakeholders in the planning process;
- comparable costs to cost to conventional solutions,
- Combine opportunities for recreation and aesthetics which can also improve public perception of WSUD.

Lloyd et. al (2002) refer to techniques that achieve WSUD as *Best Management Practices* (BMP), which can be non-structural and structural. Non-structural techniques are identified as environment and urban policy development, environmental considerations on construction sites, education and staff training, community education and enforcement programs. Structural techniques relate to physical stormwater treatment measures to 'collect, convey and detain stormwater to improve water quality and/or provide a reuse function' (p7). As a practice this enables appropriate land-use requirements, including the layout and arrangement of stormwater management to match landscape characteristics (S. D. Lloyd, Wong, & Porter, 2002).

WSUD involves a treatment train. This is the sequencing of multiple structural BMPs to achieve optimal removal of pollutants (i.e. distribution rather than toxic build up in a single location) and flow management across a catchment (S. D. Lloyd et al., 2002). There are several types of structural BMPs (i.e. WSUD treatment measures), which have various functions. Measures that are commonly used in Greater Metropolitan Melbourne often in combination as a treatment train include rainwater tanks, bioretention swales, ponds/ shallow lake systems, constructed wetlands, sedimentation basins, sand filters, vegetated swales, bioretention basins/ rain gardens, and bioretention swales (Melbourne Water, 2013).

Table 2.2 outlines two examples of treatment measures suitable for dense urban areas, along with their preferred environmental siting for optimal functioning (i.e. BPPs).

Table 2-2: WSUD Treatment Measure Examples. Adapted from 'Water Sensitive Urban Design Guidelines: South Eastern Councils' by Melbourne Water, 2013.

			Function	Spatial Dimension	Preferred Siting
Measure	Bioretention Swales		Transport stormwater and facilitate its treatment through filtration.	Form part of landscaping, without removing development potential, such as the median strip of divided roads.	Best suited to slopes with a gradient of up to 4% or where velocities during major flood events do not exceed 2 m/s.
	Bioretention Basins and Raingardens		Treat stormwater by passing stormwater through media for filtration, commonly vegetation, with extended detention and some biological uptake	Are designed at a range of scales and shapes and can be positioned at regular intervals, underground or at drainage outfalls. They are an alternative for wetlands where land for a treatment system is limited.	Requires a permeable soil to allow for infiltration of stormwater. When located close to significant structures, surrounding soil should be tested for its hydraulic conductivity to minimise leakage from the system.

2.4. Conceptual Framework on Drivers and Barriers

A review of seven studies investigating barriers and drivers for realising BG Infrastructure has informed the conceptual framework for this thesis. Specifically, theme categorisation of barriers and drivers and methodology to undertake further investigation of the topic. Methodologies used across the studies differ and include literature reviews, policy reviews, transitions analysis, online surveys, interviews and modelling summarised in Table 2.3.

This section highlights the studies' findings of planning instrument issues. Many of the studies discuss challenges of planning instruments together with other barriers and drivers, which form part of the broader governance landscape that the instruments work within and are addressed separately as 'influential factors' within the following sub-section. Issues experienced for planning instruments in the studies relate to two main topics. The lack of detailed guidance for BG Infrastructure, and a lack of coherency and integration between instruments, outlined below.

1. A Lack of Detailed Guidance About Ecosystem Services

Despite the presence of broad aims and concepts related to BG Infrastructure, there is a lack of scientific based actions and standards, especially in addressing the improvement of ecosystem services. This is attributed to the earlier paradigm of managing urban stormwater as wastewater, which is reflected by centralised drainage infrastructure. Kuller et al. (2017) recognise that BPPs which informs the design and site selection of WSUD needs to be further addressed. This is because it significantly influences the overall WSUD's suitability, its effectiveness and overall performance for ecosystem services. They argue that frameworks and models are needed to guide BPP, to link benefits of ecosystem services with measurable indicators. It is suggested that limited attention to BPP and ecosystems in literature could be related to the complexity of planning, often considered a statutory rather than academic practice (Dhakal & Chevalier, 2017).

Table 2-3: Summary of Methodologies used in Prior Studies

Study	Methodology
(Dhakal & Chevalier, 2017)	Literature review and legislation survey for the implementation of BG Infrastructure in 10 US cities.
(Kiparsky et al., 2016)	Online survey with Californian wastewater utility managers to assess innovation deficits in urban water organisations and to identify attitudes towards experimentation. The survey addressed management practices, governance structure, budget, perceptions of innovation and major challenges in technology adoption. And developed an innovation index for each utility.
(Kuller et al., 2017)	Literature review on what constitutes BPP for BG Infrastructure. Development of suitability framework to address appropriate site conditions, and factors why a place needs infrastructure (i.e. to manage stormwater for environment protection).
(Morrissey et al., 2018)	Study of spatial planning instrument transitions in the case studies of Melbourne (Australia) and Ireland using MLP and TM frameworks. Aim to identify barriers to sustainability and processes of 'inertia, innovation and landscape dynamics' within planning systems (p56). They question what insights socio-technical transitions concepts provide to the revaluing of planning as a tool for change.
(Qiao et al., 2018)	Literature review to investigate the role of governance processes in the slow implementation of BG Infrastructure. Using the Policy Arrangement Model, they summarise challenges based on actors, resources, rules of the game and discourses.
(Schuch et al., 2017)	Content analysis to evaluate planning approaches for flood management on green open space areas in case study regions of South East Queensland, Melbourne and Perth, Australia.
(Wihlborg et al., 2019)	Interviews with practitioners involved in BG Infrastructure from municipalities and water utilities and using MLP as an analysis framework.

2. A Lack of Coherence and Integration Between Policies

There is limited consistency between planning strategies across departments and governance levels, and an absence of multiple perspectives and stakeholder views, which reduces the legitimacy of controls (Morrissey et al., 2018). The inconsistent approaches and requirements between policies for stormwater complicate the implementation of novel solutions (Dhakal & Chevalier, 2017), and the impact of urban areas and their dependency on water resources is experienced at a local and catchment level which is not reflected in instruments (Schuch et al., 2017). A lack of spatial integration limits available land to accommodate BG Infrastructure, which could be reversed if land use zoning plans and overlays supported BG Infrastructure implementation (Dhakal & Chevalier, 2017; Kuller et al., 2017). Morrissey et al. (2018) argues the need for place specific sustainability principles, to promote innovation, synergies and cooperation, that go beyond persisting governance challenges, particularly the disconnect between planning practice and other policies that prioritise economic interests. Kuller et al. (2017) recommend better integration between land use planning, green open space planning, and water resource management.

2.4.1. Influential Factor Themes

From the review of studies, this thesis identifies that other influential factors as barriers and drivers, can be categorised into five themes: economic, environmental, institutional, social and technical as illustrated in Figure 2.3.

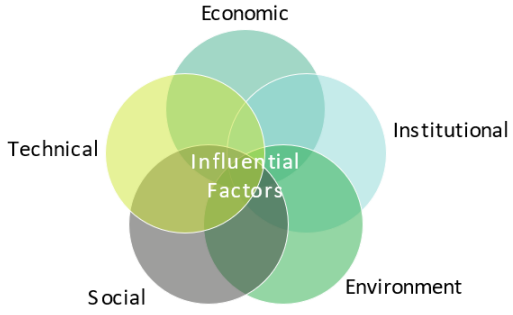

Figure 2.3 Thesis Conceptual Framework of Influential Factors for Planning Instruments.:

This section elaborates these themes, describing the categorisation with relevance to urban planning, and for emphasis reoccurring topics are italicised. The overview of themes provides a background knowledge about influences on realising BG Infrastructure but is not exhaustive. As terminology for sustainable urban stormwater management differs between local contexts (Fletcher et al., 2015), for simplicity the term BG Infrastructure is used.

Economic Factors: relate to the availability of finance to support the implementation of BG Infrastructure.

Availability of funding is a crucial factor and impediment to BG Infrastructure implementation, where municipalities may be restricted in allocations from the centralised government, and there is a lack of evaluation criteria to communicate benefits which could beneficially promote investment (Qiao, Kristoffersson, & Randrup, 2018). A limited government budget to incentivise stakeholders' implementation of BG Infrastructure reduces the adoption of the technology especially as the approach is perceived as more expensive than conventional drainage and leads to change resistance. Kiparsky et al. (2016) recommend incentives though formal networks such as trade associations in response to perceived finance risk for innovation.

Perceived benefit of BG Infrastructure for ecosystem services is a persisting barrier, as economic interests of the existing governance model are a priority over the aspirations of sustainability transitions (Morrissey et al., 2018). There is a higher perception of risk with the approach compared to the centralised system. The perceived financial risk is often in relation to the cost of maintenance and performance, which results in longer pay-back periods for investments (Dhakal & Chevalier, 2017).

Environmental Factors: relate to influences on the natural and built environment that promote or deter the implementation of BG Infrastructure.

Environmental protection is a driver to minimise the impact of urban development on stormwater flow and quality. However, challenges for implementation arise as a result of variable biophysical site conditions, which makes each site unique in terms of soil type, slope, hydrology, climate, urban density and ecosystem services (Kuller et al., 2017). Multi-benefits and adaptation to climate change impacts such as flood risk are a driver, however

when benefits are not measured, there is resistance as the approach is perceived as more expensive (Qiao et al., 2018; Wihlborg et al., 2019).

Urban densification is a driver for measures to manage higher volumes of stormwater. It can also be a barrier when pressure to deliver more housing is a priority on municipality agendas, which is argued to have a more direct impact on peoples' lives. As a result thorough planning for optimal BG Infrastructure may not occur (Wihlborg et al., 2019), and there is likely to be limited space to realise measures. Space limitations however, can also promote more innovative solutions (Qiao et al., 2018).

Institutional Factors: relate to governance and organisational processes (i.e. rules, norms and conventions) that influence the implementation of BG Infrastructure measures.

Governance is a barrier when there is restrictive *procedures* and unclear leadership, which is further challenged by a predominance of centralised grey infrastructure often characterised with a technocratic approach (Dhakal & Chevalier, 2017; Kiparsky et al., 2016; Kuller et al., 2017). Compliance with stringent water quality standards further limits innovation in management decisions to implement more novel BG Infrastructure solutions, which relates to a lack of flexibility in system design (Kiparsky et al., 2016).

Division of *responsibilities* plays a critical role in realising BG Infrastructure from its design to implementation, however it can be negatively impacted by mistrust between private and government players, as well as private land ownership to realise outcomes, 'silo thinking' of departments, creating fragmented resource allocation (Qiao et al., 2018; Wihlborg et al., 2019). Political interest can further slowdown and block change which can impact new implementation and maintenance of existing measures (Kiparsky et al., 2016). Project champions are an important driver to empower change in policy and realisation of measures through communication with leading actors the planning process (Qiao et al., 2018). Dhakal & Chevalier (2017) recommend that in addressing barriers with institutional arrangements, regional – local policy and public awareness programs could be helpful to assist institutional reform.

Knowledge transfer is a driver that uses research institutions to assist with resources, investment, experimentation and *innovation* between authorities and industry practitioners (Qiao et al., 2018). A *lack of knowledge* and experiences with BG Infrastructure between actors is a significant barrier, which can result in the weak coupling of knowledge and local conditions. Locally appropriate knowledge transfer is promoted as essential so that failures do not reduce confidence and reluctance in the approach (Qiao et al., 2018). Schuch et al. (2017) observe that BG Infrastructure demonstration and pilot projects are negatively influenced by policy processes, interactions between actors, and organisation roles, more so than technical aspects for physical implementation. They suggest the solution lies with researchers acting as knowledge brokers and working to influence social capital amongst local stakeholders, and as argued by Wihlborg et al. (2019) to nurture a culture of experimentation.

Social Factors: relate to the perception and acceptance of BG Infrastructure measures that can influence their implementation.

Public *awareness* on the value of BG Infrastructure is influential in encouraging the uptake of measures (Dhakal & Chevalier, 2017; Kuller et al., 2017). Acceptance of the approach has a positive role, which can be influenced by political stability and social cohesion (i.e. when a community take care of their surrounding environment) and can be strengthened through community interaction (Dhakal & Chevalier, 2017; Kuller et al., 2017).

Technical Factors: relate to the performance of BG Infrastructure as a technology, which can promote or dissuade inclusion of measures in the planning and design process.

Adaptability of the existing system can be a barrier to implementation. Such as the difficulty with implementing BG Infrastructure in a highly developed urban area, with minimal and fragmented remaining open space areas (Schuch et al., 2017). Reliability is perceived as another system barrier, with concerns about low performance (Dhakal & Chevalier, 2017).

2.5. Research Direction

The research direction and questions that this thesis adopts has been informed by key findings from literature and identified knowledge gaps, outlined below.

2.5.1. Key Findings from the Literature Review

The literature provides insight of the following key findings:

- For adaption governance to be most effective it needs to be proactive and long term, but also reflexive, adopting hypothesis testing, monitoring and evaluating of approaches to uncertain climate change events.
- Socio-technical transitions as part of transition theory provide a useful lens to observe how new technologies such as BG Infrastructure can progress from a niche to a regime. Observing governance processes as a landscape for the transition forms an important, yet complex part. The MLP and TIS framework can provide guidance on how to describe the governance landscape.
- Good practice urban water governance is equitable, economically efficient, politically provides equal rights to stakeholders and protects ecosystem functions. It is key in securing future water supplies for cities as part of climate adaptation efforts, and more focus should be placed in its improvement.
- A study of urban water governance in OECD countries identifies the most significant challenges are related to (1) institutional fragmentation, (2) ambiguous legislation, (3) poor implementation of multi-layered governance, (4) limited capacity at local level, (5) unclear allocation of roles and responsibilities, (6) fragmented financial management and (7) uncertain allocation of resources. Other issues included the lack of long-term strategic plans and insufficient resources to measure performance resulting in weak accountability and transparency (Koop & van Leeuwen, 2017)
- Municipalities are well placed to progress change in stormwater management because of their representation of local interest, local catchment knowledge and role as policy implementers, regulators and managers of stormwater infrastructure.
- Planning instruments are important in guiding preferred built environment outcomes that can support the integration of BG Infrastructure. Planning instruments have several typologies that guide, incentivise and control.
- The design of WSUD should be in accordance with BPP (i.e. informing site selection) and BMP (i.e. implementation) for optimum functioning.
- Studies of barriers and drivers experienced for progressing BG Infrastructure highlight two major challenges for planning, these include a lack of detailed guidance for ecosystem services, and a lack of coherence and integration between policies. Other factors influencing the governance landscape also play an important role and in this thesis are thematically categorised as economic, environmental, institutional, social and technical.

2.5.2. Research Gaps

Sustainability transitions is a recent and developing area of scholarly research which provides a broad scope for further investigation. Many papers admit not knowing much about governance processes, and that the overlap of planning and governance is complex and usually a statutory planning issue. As municipalities have an important role in stormwater management systems, a closer study of governance networks and planning instruments at a local government level is needed to address this gap. This will build knowledge about how influential local planning controls are in realising BG Infrastructure.

A study of barriers and drivers influencing local planning instruments will also help identify opportunities on how to reform instruments to make them more effective. For example, how to address an optimal coupling of ecosystem services with BG Infrastructure design using planning instruments. Studies recognise that BPP is an area that needs further development, and this could be an area where planning instruments assist.

2.5.3. Research Questions

Research questions seek to address research gaps and form the line of investigation for this thesis.

Research Question No.1: How influential are local planning instruments in the delivery of BG Infrastructure?

Hypothesis No. 1: Local planning instruments are influential in the delivery of BG Infrastructure as they form part of development approval processes. However, the level of influence is related to how directly the instrument addresses BG Infrastructure and its inclusion of detailed guidance.

Research Question No. 2: How can local planning instruments be strengthened to address perceived barriers, and drive the implementation of BG Infrastructure?

Hypothesis No.2: Local planning instruments can address influential factors that form part of the governance landscape, to support the transition of BG Infrastructure from a niche to regime stormwater management approach.

2.6. Chapter Summary

This chapter has provided an overview of literature that underpins this thesis. The literature recognises that although BG Infrastructure is a well-known and accepted approach for sustainable urban water management and is critical in addressing future stormwater impacts, several challenges stand in the way of the practice transitioning from a niche to a regime stormwater management approach. Prior studies highlight challenges of existing planning processes and instruments, but also additional factors which this thesis thematically categorises as economic, environmental, institutional, social and technical. Although many studies have been undertaken to understand persisting barriers and drivers to BG Infrastructure, research has been limited in investigating BPP. This thesis seeks to address this area of inquiry, and its implications for planning instruments.

3. Research Framework

This chapter details the research methodology to investigate the influence of local planning instruments on the adoption of Blue - Green (BG) Infrastructure in dense urban areas. To consider the complexity of place -specific governance and planning influences, this thesis examines two empirical case studies in Melbourne, Australia. A mixed approach was used for data collection and analysis encompassing a document review, semi-structured interviews with experts, direct observation through a field trip and a follow-up online questionnaire to validate interview responses. Thematic analysis of the interview and questionnaire results informs recommendations and policy implications.

3.1. Methodology Overview

The method undertaken in this thesis was established from the theoretical framework outlined in chapter 2, guided by previous studies investigating the complex contextual conditions of governance and planning processes. Specifically, investigating how influential local planning instruments are in physically realising BG Infrastructure measures.

The multiple case studies approach adopted by this thesis, has been informed by the guide: '*Case Study Research: design and methods'* by Yin (2003). The guide defines case studies as empirical research that '...investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident' (Yin, 2003, p13).

As governance is a complex part of planning decisions, this thesis uses case studies for a descriptive insight of barriers and drivers experienced in the realisation of BG Infrastructure. Yin (2003) criticises case study research for its inherent bias. To address this criticism, Table 3.1 lists the biases in the case study guide, and the counter response that this thesis adopts.

This thesis addresses constructs of validity and reliability in social science research, which can be achieved using method testing (Yin, 2003). For validity in data collection, this research uses multiple sources to cross-compare evidence and to build a chain of evidence that is logical to follow. To achieve internal validity in data analysis, rival explanations have been used to explore alternate view for a balanced explanation. For reliability, a case study database has been created. To achieve external validity, it is suggested that the research approach be replicated to other cities, however, this replication is not within the scope of this thesis due to time constraints for the research project.

As an overview, outlined by Figure 3.1, the methodology of this thesis comprises a literature review, two case studies using mixed method data collection and analysis recommendations. Each phase is detailed in the following sub sections of this chapter.

Table 3-1: Study Bias and Counter Respons

Study Bias	Counter Response
The researcher's prior knowledge of urban planning informing hunches on challenges and opportunities.	Adoption of an interview protocol to provide logical steer to interview questions.
Study participants' bias that may not be representative of other practitioners.	Facilitation of an online questionnaire to distribute amongst a larger sample size of practitioners, to validate and quantify results in a representative way.
Case study selection and framing of issues bias; to display the preferred outcome of the topic.	Case studies are selected as a descriptive tool to generalise place-specific trends, with a narrow focus on precinct/development scale case studies rather than city-wide plans.
Analytic generalisation of the case studies is to a small number of cases.	The method undertaken in this thesis is recommended to be replicated in other locations in future studies.

As an overview, outlined by Figure 3.1, the methodology of this thesis comprises a literature review, case studies using mixed method data collection and analysis recommendations. Each phase is detailed in the following sub sections of this chapter.

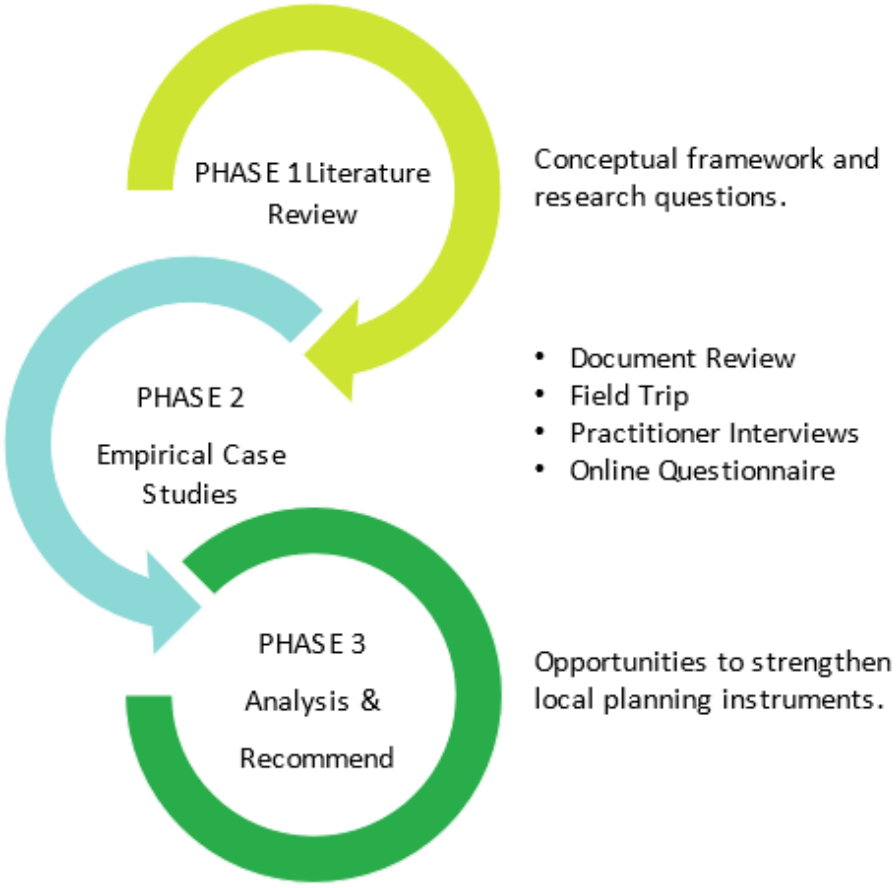

Figure 3.1: Summary of Thesis Methodology

3.2. Phase 1 - Literature Review

Addressed in chapter 2, this first phase of research involved the review of literature pertaining to climate adaptation, water governance and persistent barriers and drivers for BG Infrastructure. The varied contributors provided the theoretical framework for this thesis, informing research assumptions. The literature represents the largest component of secondary data, collated from scholarly, government and non-government publications.

3.2.1. Scholarly Literature

Academic journals were sourced from disciplines in climate adaptation, urban design, planning, transitions theory and governance. Journal articles were the largest contribution to knowledge on BG Infrastructure, as they provided an in-depth understanding of previous research studies. Literature was sourced through an online journal database using search terms including 'barriers and drivers', 'Water Sensitive Urban Design', 'blue green infrastructure', 'decentralised water infrastructure' and 'sustainable urban water management'. The results yielded a large selection of international studies dating back to the early 2000s to the present (2019). Using the search term 'Melbourne' as an additional search term, yielded a significant number of university publications from Monash University and RMIT University from their water governance research divisions, in connection with the Cooperative Research Centre (CRC) for Water Sensitive Cities.

Physical books and e-books were sourced through the central Hamburg University library database Beluga on topics including Water Sensitive Urban Design (WSUD), governance and sustainability transitions.

3.2.2. Government and Non-Government Publications

Government and non-government websites were used for the investigation of case study specific policies, strategies and cooperative groups associated with WSUD in the Melbourne context. Additionally, documents and articles from internationally recognised advisory bodies were investigated for international contributions on water governance and the climate adaptation agenda.

3.2.3. Research Assumptions

Informed by literature, the following five assumptions have been adopted to frame the scope of this research:

Assumption No. 1 - Melbourne is a likely suitable case study to answer the research questions

The Urban Water Transitions Framework by Brown et al. (2009) identifies Melbourne for proactively transitioning towards the vision of a Water Sensitive City. Notwithstanding, Melbourne experiences several hurdles in their efforts (Morrissey et al., 2018), which as a forerunner city, presents an interesting study case for further investigation.

Assumption No. 2 - Local planning is a likely influence on BG Infrastructure

Local planning is well placed to drive innovative approaches to its water infrastructure, pertinent to its role of guiding land development, policy making and management of local drainage systems (Morrissey et al., 2018). Planning instruments have great potential to progress the agenda of BG infrastructure at this level.

Assumption No. 3 – Planning instruments are likely to be influenced by their place-specific landscape

Planning instruments are influenced by the place-specific landscape they operate within. The Multi-Level Perspective framework in transitions theory identifies the landscape as encompassing cultural patterns, the economy, legal structures, political developments and the natural environment (Twomey & Gazulusoy, 2014). This thesis defines the system landscape to observe the influence of planning instruments.

Assumption No. 4 - Urban Densification is likely to be an opportunity for implementing BG Infrastructure measures and should guide case study selection

Increasing development pressure in existing urban areas has exacerbated stormwater drainage issues (Larsen et al., 2016; Newton, 2018). New residential buildings within these areas provide a significant opportunity to integrate BG Infrastructure measures in their design to alleviate and improve the quality of urban stormwater run-off.

Assumption No. 5 – Pilot and Demonstration Projects are likely to provide rich information to inform the research.

Pilot and demonstration projects play an important role in mainstreaming innovations and raising awareness of BG Infrastructure benefits and possibilities (de Graaf & van de Ven, 2012; Farrelly & Davis, 2009). As pilot projects adopt a bold approach in experimentation, and are important in progressing technological change, they are an insightful to observe ambitious projects which push the boundaries of the regime (Binz et al., 2012).

3.3. Phase 2 – Empirical Case Studies

To investigate the complexity of place - specific governance and planning influences this study draws upon two qualitative case studies incorporating innovative BG Infrastructure in Melbourne, Australia. The Inkerman Oasis development is retrospective, and the other, the Fishermans Bend urban renewal is current and ongoing with a masterplan horizon to 2050. The contrast in the projects provides an insight of persisting challenges despite advances in BG Infrastructure science and technology. The projects share a similar socio-geographic landscape, both located within Greater Metropolitan Melbourne, south of the city centre and sharing governance frameworks.

3.3.1. Case Study Selection

The retrospective Inkermann Oasis study case was initiated in 1996 and occupied in 2003. The project involved urban renewal of a brownfield site into retail and residential apartment units with an element of social housing (Farrelly & Davis, 2009). The project at the time of its design and completion represented a significant contribution to sustainable urban development which was awarded national and international industry recognition (Aspin, 2007; Farrelly & Davis, 2009). Led by an ambitious vision, with strong governing leadership including the local governing authority, the City of Port Phillip (CoPP), the project pushed to trial new ideas for exemplar outcomes. Institutional systems were not yet in place to support new ideas, and so the development is considered a pioneer (Farrelly & Davis, 2009). For this reason, it presents an interesting study case as an early example of innovation and experimentation, demonstrating challenges and barriers at that time. BG Infrastructure incorporated on the site includes treated greywater use for toilet flushing and subsurface landscape and garden irrigation, stormwater flow and quality management through wetland landscaping and roof gardens (Mitchell, 2006).

Fishermans Bend in contrast is a current and ongoing renewal precinct project. Led by a visionary masterplan to the year 2050, with the objective of transforming the industrial precinct to a mixed use and residential apartment community (State Government of Victoria, 2019). Discussion for the detailed planning that supports the masterplan's vision is ongoing, with the CoPP and the City of Melbourne (CoM), taking part in this process as respective local government areas (City of Port Phillip, n.d.-a). Challenges in existing governance frameworks have complicated planning for ambitious new approaches for BG Infrastructure in the precinct (State Government of Victoria, 2018). These current discussions highlight challenges to progressing the agenda of sustainable urban water management, in a renewal area which experiences critical flood issues. As a study case, the project is used to descriptively highlight persistent challenges experienced by BG Infrastructure in the context of Melbourne.

To investigate the local governance framework for the case studies, embedded units of analysis are used, these being the 'influence' of local planning instruments and the 'influence' of additional factors. Data collection methods are outlined in the following sub-sections.

3.3.2. Document Review

For a background understanding of the study cases, documents in the form of government plans, reports, strategies and policies were retrieved from various government and non-government websites. These documents informed for each case study, the assembly of an:

Instrument Map

The mapping provided an overview of instruments related to stormwater management at a national, state, regional (i.e. two or more local governments) and local government level. The categorisation of instruments is outlined in Table 3.2. This categorisation is a simple adaption of the complex planning tool kits developed by Carmona (2017). The mapping illustrates the governance frameworks for stormwater over the projects' time period, to highlight changes

Table 3-2: Instrument Mapping Categorisation

			Examples from Instrument Map
Instrument Type	Formal: Local Mandates	*Strategies* (i.e. development plans): Regulatory requirements set by local strategies (i.e. frameworks and actions) that are used in local government assessment processes.	Strategic Council Plans, Greening of Public Spaces; Greening of Private Spaces; Water Plans and Climate Adaptation.
		Planning Schemes (i.e. development management instruments): Regulatory requirements set by local planning schemes (i.e. prescriptive measures) that are used by local government to determine development approval.	Municipal Strategic Statement; Contract Agreements; Overlays; Precinct Planning; Sustainable Development; Stormwater Management.
	Informal	*Incentives* promote WSUD measures but are not regulated and use financial benefits to promote WSUD.	Bonuses; Exemptions and Sponsors.
		Public Relations include initiatives that promote WSUD measures, but are not regulated, such as best practice guidelines.	Awareness; Collaborative Research; and Best Practice Guidelines.

and identify planning instruments at a local government level.

Stakeholder Map

This map provides an overview of key stakeholders involved in the projects along with relevant planning instruments. The intent is to identify the governance hierarchy in the project, as well as stakeholder involvement from the project's design to implementation.

3.3.3. Field Trip

A site visit was undertaken for an improved understanding of each project's development scale and form.

3.3.4. Interviews

For an in-depth understanding of barriers and drivers for BG Infrastructure in Melbourne, using the two case studies as a discussion basis, semi-structured interviews were conducted with local practitioners as experts from stormwater engineering, water governance, design and planning disciplines.

The methodology was informed by Wihlborg et. al (2019) study who used semi-structured interviews with water utility and stormwater municipality staff. Interviews are similarly adopted in this thesis, for an in-depth view of governance and socio-economic conditions from the respondents' professional knowledge of BG Infrastructure planning.

Informants were purposively selected for their knowledge of and, or involvement with the case study projects. Snow-ball sampling using a gatekeeper researcher with established contacts in Melbourne was used to identify the relevant personnel for each project. On first contact basis, accompanying an introductory invitation email, respondents were provided with a permission of consent form, outlining the study intent and management of data. The interviews were undertaken over the course of one working week. All in-person interview respondents (eight persons) provided consent for their responses to be audio recorded and used in this study. One telephone interview was also undertaken but did not include an audio recording or permission for using the response.

To respect anonymity of responses, interviewee comments are identified according to their representation, that being local government (LG), water retailer (WR) and private practitioner (PP).

Interviews lasted on average 45 minutes and were conducted with a standardised interview protocol. The protocol was structured in three parts and addresses governance aspects of transition analysis, including the identification of relevant actors, networks and institutions involved in the study cases. Discussion aids that sketched preliminary ideas on important stakeholders, instruments, as well as barriers and drivers were also used. To be consistent with local terminology for decentralised stormwater management, WSUD as a term was used to describe this practice through the interviews. Appendix A reproduces the consent form, interview protocol and supporting material. The main parts of the interview are outlined in Table 3.3.

Table 3-3: Interview Procedure Overview

Part	Intent
A – Introduction	• Introduction to study topic with questions about respondent knowledge and experience with decentralised stormwater management, and the case studies.
B - Instrument and Stakeholder Mapping	• To identify relevant stormwater actors and planning instruments for the case study projects, adding to the preliminary instrument and stakeholder map discussion aids.
C - Implementation Barriers	• To identify barriers and drivers for the physical implementation of BG Infrastructure. A list of barriers and drivers from the review of literature was provided as a guide.

At the interview's conclusion, respondents were invited to participate in a follow-up online questionnaire and were requested to distribute the questionnaire among Melbourne colleagues working with WSUD.

3.3.5. Online Questionnaire

This methodology was informed by a Kiparsky et al. (2016) study which used an online questionnaire with water utility managers to quantify opinions about innovation in water governance. An online questionnaire is similarly adopted in this thesis to enhance the respondent data set to be more representative and validate results from the semi-structured interviews. It also provides the option of anonymity to encourage respondents to answer with less restraint.

The intent of the online questionnaire was to quantify 'influence' of different planning instrument typologies and additional factors on physically realising WSUD measures (i.e. WSUD measures are built). A Likert Scale was provided to rate influence where : 1 = No influence (i.e. WSUD is not realised) 2 = Weak influence (i.e. WSUD is rarely realised) 3 = Moderate influence (i.e. WSUD is realised sometimes) 4 = Important influence (i.e. WSUD is realised most of the time) 5 = Direct influence (i.e. WSUD is realised). Where respondents had no knowledge there was a 'no opinion' option. The content of the questionnaire was informed by the practitioner interviews and a second post-interview document review, which led to further inclusions on the instrument maps.

Email invitations were disseminated using several gatekeeper contacts in Melbourne established through the practitioners interviewed. Administrative staff at Melbourne-based research and peak industry bodies (i.e. Clearwater and Stormwater Victoria), were also contacted to request circulation of the questionnaire to members and personnel. By participating in the questionnaire, respondents were informed that they provided consent for their responses to be used as part of the study, and their responses would remain anonymous.

The questionnaire had an approximate duration of 10 minutes. The response collector was open over a two-week period, supported by follow-

Table 3-4: Summary of Thesis Methodology

Part	Intent
A – Planning Instruments	Respondent opinion on how influential local planning instruments are in physically realising WSUD measures. The local instruments included in the questionnaire represent the results of the instrument mapping for the case study projects, along with current examples from CoM and CoPP.
B – Additional Factors	• Respondent opinion on how influential additional factors that are barriers and, or drivers are in physically realising WSUD measures. The list of factors was derived from key contributory literature, the document review, and practitioner interviews, grouped within five categories. The complete list of factors and their explanation, is reproduced in Appendix E. • Respondent nomination of the factor category (i.e. economic, environmental, institutional, social or technical) they perceive as the most influential driver, and independently, the most influential barrier to realising WSUD measures. The intent of the question was to identify two key areas where change can be addressed in planning instruments.

up emails to key informants. The questionnaire is reproduced in Appendix B and is summarised in Table 3.4.

3.3.6. Phase 3 – Analysis & Recommendations

The analysis of findings involved two parts to address the research questions, outlined below.

Part 1 – Description of Melbourne Case Studies

To understand Melbourne's stormwater landscape and how WSUD as a niche operates within the existing regime, the case studies are described according to transition theory using a hybrid of the Multi-Level Perspective (MLP) and Technological Innovation Systems frameworks (TIS). Specifically MLP is used to describe the system that planning instruments operate within that impacts WSUD adoption following de Haan & Rotmans (2011) description (i.e. landscape, regime and niche). The TIS framework is used describe the structural dimensions of the system institutions and infrastructure guided by Wiezorek and Hekkert (2012) outline.

Part 2 – Interview and Questionnaire Findings

Interview responses are analysed using thematic analysis. The conceptual categorisation of barriers and drivers (i.e. economic, environment, institutional, social and technical) is used to highlight reoccurring themes in responses. The results are compared with the questionnaire results to observe similarities and differences, major findings of perceived influence of instruments and its policy implications.

3.4. System Boundaries

This study was conducted to gain broader insight into potential issues with planning instruments, using the following as a guide:

Realisation of BG Infrastructure: This involves the building of WSUD and encompasses design, planning and construction aspects of WSUD implementation, but does not extend to detailed operations management, which is beyond land use planning.

'Influence' of Planning Instruments and Factors: *Influence* in this thesis refers to the pull, command and authority that factors and instruments have in the decision-making for the building of BG Infrastructure. The measure of influence is subjective for each respondent, however, provides an enriching insight of perceived issues.

Additional Factors: Many factors are recognised as influencing the realisation of BG Infrastructure. The goal in this study is to map persisting factors and then investigate their influence using two case studies.

3.5. Chapter Summary

This chapter has detailed the methods adopted for this research. The methodology uses empirical case studies to investigate persisting barriers on the realisation of BG Infrastructure in Melbourne, a city recognised for being progressive with a Water Sensitive City agenda. One retrospective and one current case study were chosen to see how the realisation of WSUD over time has changed. That is, have lessons been learned? or are the same persisting barriers continuing? Local planning instruments are important tools in realising WSUD and are investigated to see how they can be further strengthened.

Recognising that governance and decision-making operates as a complex system, the influence of additional factors that are conceptualised in the literature review (i.e. economic, environment, institutional, social and technical) are also investigated. Chapter 4 introduces Melbourne's stormwater landscape and case studies guided by transition theory.

4. Melbourne Case Studies

This chapter introduces Melbourne's stormwater management system using transitions theory to describe complex interactions that influence the realisation of Water Sensitive Urban Design (WSUD). A hybrid between the Multi-Level Perspective (MLP) and Technological Innovation Systems (TIS) frameworks of transition theories is used to describe Melbourne's stormwater landscape in terms of its prevailing stormwater regime and the emergence of WSUD as a niche, illustrated by two empirical case studies.

Mapping of stakeholders and planning instruments undertaken for the respective case studies has informed this chapter. Interview responses provided an understanding of key stakeholders and instruments, which was later complemented with reviews of online documents to complete information gaps. References to interview responses are abbreviated to the following: WR: Water Retailer Representative; LG: Local Government Representative; and PP: Private Practitioner.

For the complete instrument maps, refer to:

Appendix C: Inkerman Oasis stakeholder and instrument map (retrospective project)

Appendix D: Fishermans Bend stakeholder and instrument map (current and ongoing project).

4.1. Melbourne Stormwater Landscape (Macro)

The MLP framework is used in this Section to describe Melbourne's stormwater landscape as a system to provide an overview of complex influences on its governance. The prevailing stormwater management system is the regime (i.e. institutions, technologies and practices) and WSUD is in comparison the novel approach (niche). This section outlines aspects of Melbourne's stormwater landscape including the city's density patterns, climate and precipitation trends and the current policy environment for stormwater management.

4.1.1. Density Patterns

Melbourne is the capital city of the State of Victoria, located on Australia's eastern seaboard. The metropolitan area of the city spans 9,990km² and has a growing urbanising population of 4.9 million inhabitants with an expected increase to 8 million by 2050 (Victoria State Government, 2017). Current figures (2017-18) show that Melbourne's residential potable water use is approximately 161 litres per person per day, which is above the Victorian Government target of 155 litres (DELWP, 2019d).

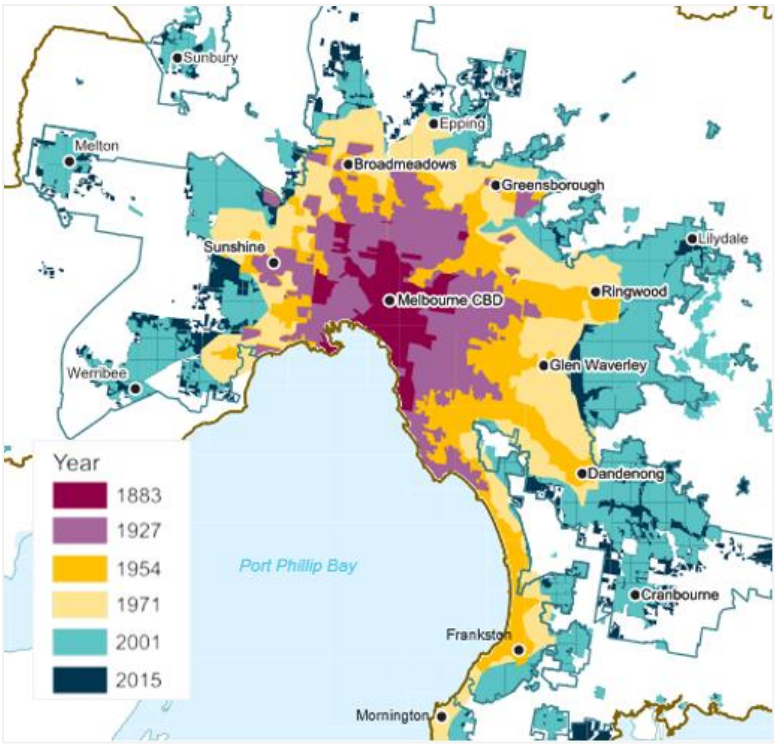

Figure 4.1: Melbourne's Growing Urbanisation. Image from 'Metropolitan Planning Strategy: Plan Melbourne 2017 – 2050' by Victoria State Government, 2017, p.4.

Plan Melbourne 2017 - 2050 the State Government's strategy for the city's future development will locate higher density housing in and around existing urban areas to create '20 minute neighbourhoods' that are well serviced by jobs and transport (Victoria State Government, 2017). Population growth in already dense urban areas will increase surface imperviousness of these areas up to 43% by 2051 compared to 2011 levels (DELWP, 2018a). Figure 4.2 illustrates the steady urbanisation of the city across the Metropolitan area.

As impervious surfaces disrupt the natural water cycle, urban stormwater runoff is anticipated to rise from 700 GL in 2011 to 1,006 GL by 2051. Impervious areas include roofs, roads as well as other hard surface coverings such as pavements. Most of Melbourne's drainage system was designed to manage one-in-five-year heavy rain events, and so the additional volume is expected to cause more flash floods, particularly city areas built before 1970 which are without overland flow paths. Already annual average damage from flooding in Melbourne is reported to cost close to AU $400 million (DELWP, 2017).

4.1.2. Climate and Precipitation

Melbourne experiences a temperate climate based on the Köppen climate classification system (Australian Bureau of Meteorology, 2016), with usually high rainfall during winter months and low rainfall during summer months and an average precipitation of 400mm – 1,000mm per year. Compared to historical conditions, however, the city is experiencing a reduction in cool seasonal rainfall from April to October, and more rain in the summer months (DELWP, 2018). Long-term trends since 1900 (see Figure 4.3) highlight the impact of climate change for Australia, particularly the variability of rainfall patterns and rise in warm temperatures.

Melbourne's climate is becoming increasingly drier with periods of extreme heat. The impacts of heat is a major topic for Australian cities. In response to urban heat impacts in Melbourne's city areas, the State Government has released high resolution mapping of urban vegetation (i.e. tree, shrub and grass cover) at land parcel level. The intent of this mapping is to track the presence of vegetation cover over time and to identify communities that are vulnerable to heat impacts (DELWP, n.d.). The mapping highlights the intensity of heat experienced by city dwellers and provides opportunities to support evidence-based planning for urban greening intervention.

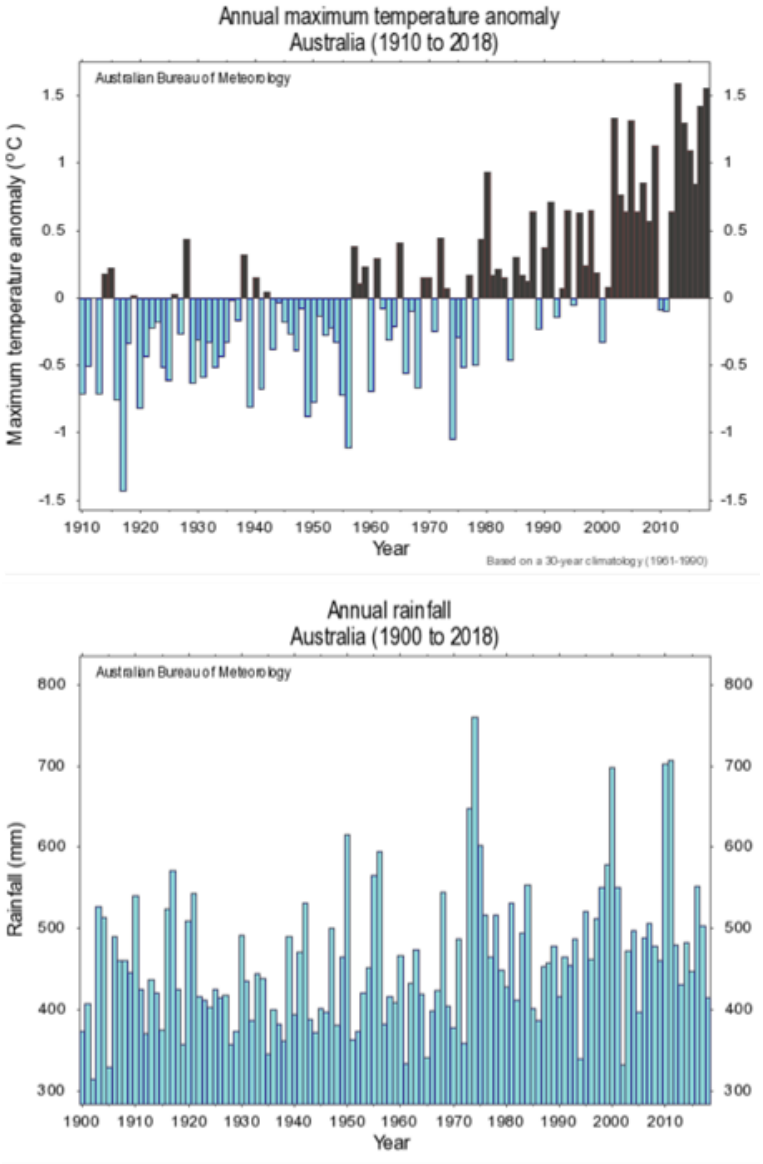

Figure 4.2: Australian Climate Change Series Graphs from 1900 to 2018. Image from Australian Bureau of Meteorology, 2018 (http://www.bom.gov.au/climate/change)

The Victorian Government in their guidelines for assessing climate change impacts recognise the uncertainty of future patterns and therefore the need of water resource planning to consider a range of possible future climate conditions (DELWP, 2016). Their rainfall records for the last 150 years show that Victoria has experienced several floods and prolonged droughts, with the Millennium Drought between 1997 and 2009 having the longest duration which raised water as a critical policy concern at Federal, State and Local Government levels.

4.1.3. Current Policy Environment for Stormwater Management

Over the past 15 years the Victorian water industry has increasingly adopted WSUD to manage stormwater, and more broadly IWM, which are now accepted as best practices to manage the whole urban water cycle (DELWP, 2018b). A significant contributor and precedent for WSUD as a mainstream practice in Victoria was established by the *State Government's Urban Stormwater Best* Practice Environmental Management Guidelines 1999 (BPEM) (DELWP, 2018a). BPEM, although not a technical guideline, has been praised for setting an influential precedent across the State for local governments' urban stormwater planning strategies. Among others, setting standard targets for water quality in terms of nitrogen, phosphorous and suspended sediments, increasing the recognition of urban design and its influence on stormwater quality, and for promoting three core principles in stormwater practice (Victorian Stormwater Committee, 1999, p12):

- *Preservation:* preserve existing valuable elements of the stormwater system, such as natural channels, wetlands and stream-side vegetation;
- *Source control:* limit changes to the quantity and quality of stormwater at or near the source; and
- *Structural control:* use structural measures, such as treatment techniques or detention basins, to improve water quality and control streamflow discharges

The current review of BPEM is likely to recommend an expanded range of stormwater management standards according to current science and technology (DELWP, 2018b).

In 2018 the Victorian Minister for Planning established the Improving Stormwater Management Advisory Committee to provide independent advice on planning and development controls for improving stormwater management (DELWP, 2018b). Advice was sought on provisions on how to deliver place-based (i.e. localised outcomes); increase integrated stormwater design in development submissions before approval has been granted; and guidance on how to improve compliance and implementation of WSUD in city infill developments. Evidence suggests that it is much more cost effective to achieve stormwater management in new developments than retrofit measures into established buildings. With increasing pressure to develop infill developments in existing urban areas, brownfield urban renewal precincts provide an opportunity for improved stormwater integration (DELWP, 2018b).

The Committee's recommendations report identifies the direct link between State Government mandates for local government stormwater management through Victoria Planning Provisions (VPPs) and the achievement of improved localised stormwater outcomes (DELWP, 2018a). Policy gaps in VPPs have led to local governments creating a plethora of complementary controls. This, they criticise for being inconsistent and inequitable across development types and local government areas, and for creating uncertain policy setting with unclear accountabilities.

There has also been an emergence of guidelines that seek to integrate the interdisciplinary character of policies, for example a recent State Government initiative 'Planning Green-Blue City' released in 2017 (DELWP, 2017). The guide is for municipality use to address the gap between practice and management of open space and water supplies. It identifies that local governments in Victoria have few strategies that integrate the two and provides a framework on how new strategies can be developed (DELWP, 2017). Committee recommendations included clarifying roles and responsibilities of local governments and water corporations; strengthening of compliance requirements and to improve the link of water management with urban planning.

The review of stormwater management and planning has led to notable and promising policy reforms and directions to strengthen the integration of stormwater and, more broadly, Integrated Water Management (IWM) in planning practices across Melbourne, specifically:

Inclusion of IWM requirements in the planning, design and assessment of new developments, which brings all the elements of the water cycle together, including sewage management, water supply, stormwater management and water treatment, to maximise community and environmental benefits (DELWP, 2018d).

- Extension of BPEM requirements to most development types, including infill multi-dwelling developments (DELWP, 2018d).
- Establishment of Integrated Water Management Forums for the major river catchments in Victoria. These Forums are the first of their kind and provide a platform for identifying interest areas and collaborative projects between local governments, water corporations, catchments management authorities and other important stakeholders (DELWP, 2018b). The Forums are intended to develop a whole of catchment approach in strategic directions, complement existing land planning processes, promote sectoral learning and optimise investment opportunities (DELWP, 2019c). Currently these objectives are only a framework, and more detailed actions and functions still need to be worked out.

4.2. Stormwater Regime (Meso)

Melbourne's stormwater regime represents the prevailing structures of current stormwater management practices. A TIS transition theory framework developed by Wieczorek & Hekkert (2012) has guided the description of the structural dimensions of Melbourne's stormwater regime in terms of actors, institutions, interactions and infrastructure outlined in Table 4.1. Each of the aspects addressed in this sub-section.

4.2.1. Actors

Australia is a democratic federation with responsibilities and powers divided between a central national government with individual states and territories and their local governments (Australian Government, n.d.). At a national level, the Committee of Australian Governments, a partnership between the states and territories developed the National Water Initiative in 2007 (Australian Government, 2018). The Initiative commits states and territories to innovation and capacity-building to create Water Sensitive Australian Cities, supported by national guidelines to evaluate options and promote reviews of planning and management of the urban water cycle.

Across Greater Metropolitan Melbourne stormwater management is a shared responsibility between several Victorian State Government authorities, water utilities and local government. Some key stormwater management actors are outlined.

Victorian State Government Authorities

Catchment Management Authorities provide services for integrated waterway and flood plain management across 10 catchments (Victorian Water Industry Association, 2019).

Department of Environment, Land, Water and Planning (DELWP) is the statutory State Government body responsible for urban planning and water. The water division operates in partnership with a network of government agencies and water authorities, such as the Stormwater Management Advisory Committee (DELWP, 2018a).

State Government Development Committees /Agencies are designated State Government bodies to oversee and coordinate major development such as the Fishermans Bend Taskforce and the Urban Land Corporation/ Places Victoria.

Integrated Water Management Forums recently established working groups for each major river catchments across Victoria to identify, prioritise and oversee the implementation of collaborative water project opportunities (DELWP, 2018c). The forums are supported by a Strategic Directions Statement which prioritises integrated water management opportunity projects and presents opportunities for further collaboration.

Environment Protection Authority is responsible for the quality of Victoria's environment though establishing standards by State environmental protections policies as well as facilitating programs and enforcement (Victorian Stormwater Committee, 1999).

Melbourne Water Corporation is the metropolitan drainage authority responsible for the management of all major drains and waterways, generally in catchments greater than 60 hectares in area (Victorian Stormwater Committee, 1999), with responsibilities including stormwater strategy management, operations, setting drainage infrastructure

standards to reduce flooding, and urban drainage development in partnership with municipalities.

Water Utilities

South East Water (SEW) provides drinking water, sewerage, trade waste and recycled water services to customers as well as approval for connections to the water network (South East Water, n.d.). It also develops precinct-based projects and integrated water management plans and has a proactive innovations unit Iota which is developing solutions for smart tanks and IWM.

Local Government

Each local government regulates its geographic area in accordance with powers, duties and responsibilities delegated (Australian Government, n.d.). Local governments are often referred to as councils, because the elected representatives that make up the 'council', which as a body govern each municipality area. Local government, council and municipality can therefore be used interchangeably. There are 38 local governments across Greater Metropolitan Melbourne responsible for local stormwater management for catchments smaller than 60 hectares and operate to (Victorian Stormwater Committee, 1999):

Table 4-1: Key structural dimensions of Melbourne's stormwater regime

Structural Dimensions	Sub-Categories	Examples
Actors	Victorian State Government	Department of Environment, Land, Water and Planning (DELWP); Melbourne Water Corporation; Catchment Management Authorities; Environment Protection Authority; Integrated Water Management Forums
	State Government Development Committees /Agencies	Places Victoria and Fishermans Bend Taskforce
	38 Local Municipalities	City of Port Phillip and City of Melbourne
	3 Water Retailers	South East Water Pty Ltd
Institutions and Interactions	Planning Instruments and networks	State Government sets the mandatory Victorian Planning Provisions to be followed by local governments in their stormwater management, with discretion to implement additional processes and controls.
Infrastructures	Physical Stormwater Infrastructure	Local Government stormwater and drains < 60ha and Melbourne Water regional stormwater catchments > 60ha Centralised stormwater management system with wetland treatment and release into water bodies including Port Phillip Bay.
	Knowledge and Research (including industry bodies)	South East Water pilot programs and IOTA innovation unit; Cooperative Centre for Research of Water Sensitive Cities, Clearwater, Stormwater Australia, Vic Stormwater, Australian Water Association; Monash University and University of Melbourne research programs.
	Financial	Local Government budget; developer requirement and self-funded; Federal Government funding (eg. Living Cities, Urban Stormwater Initiative Program); water retailer funded programs.

- ensure land can sustain urban development, managing approvals of developments;
- protect stormwater quality by minimising the extent of surface imperviousness and providing adequate space for stormwater detention and treatment; and
- maintain and operate local stormwater infrastructure and urban environments that discharge to the local stormwater network.

Bordering local governments often share strategies, for example, the City of Port Phillip (CoPP) and the City of Melbourne (CoM) share several memberships and policies in the management of stormwater, including membership with the *Inner Melbourne Action Plan* (Inner City Melbourne Action Plan, 2018); inner city local governments that have developed initiatives across member governance areas.

4.2.2. Institutions (Planning instruments and process)

In addition to State Government stormwater initiatives, local planning also plays an important role in the management and design of stormwater systems. There are numerous formal planning instruments that need to be considered and addressed in balance during the assessment of a development, which may directly or indirectly have an influence on WSUD outcomes. The key statutory frameworks that local governments operate within include:

- The *Local Government Act 1989 (Vic)* sets out the functions and responsibilities of local governments in Victoria including the preparation of Council plan making and enforcing laws; and
- *The Planning and Environment Act 1987 (Vic)* is the primary State Government legislation which sets out Victoria's land use planning framework.

Local government strategies are diverse and can include Council plans, greening of public spaces and private spaces, water plans, and climate adaptation. These strategies need to be addressed by developments in how their objectives are met. Some strategies provide overarching objectives and others provide quantifiable measures and procedure. For example the CoPP's *Sustainable Design Assessment in the Planning Process* strategy, provides a framework for residential and non-residential development for new buildings or extensions to existing buildings. It has stormwater management objective which align with State Government requirements and aims to reduce the impact of stormwater run-off by encouraging WSUD (City of Port Phillip, n.d.-b). It requests a plan that outlines any proposed sustainable design initiatives that will improve the overall performance of the development.

The implementation of Planning Schemes is a critical function of local governments. Planning Schemes incorporate a mix of local policies including zones and overlays but are prepared in accordance with the State's standardised VPPs (Williams, 2017). Zones establish permissible and prohibited land uses and whether a planning permit is required for development. Overlays may also apply to land and relate to a single issue such as land identified with flood risk and are considered in the assessment of a development application. Planning Scheme requirements can include Municipal Strategic Statements, contract agreements, overlays, precinct planning, sustainable development, and stormwater management. For example, the CoPP has clauses in its Planning Scheme relevant to sustainable development (i.e. *Clause 21.03 Ecologically Sustainable Development* and *Clause 22.13 Environmentally Sustainable Development*), and stormwater management (i.e. *Clause 22.2 Stormwater Management: Water Sensitive Urban Design*)

Depending on the Planning Scheme requirements for permissible use of the land, there are two types of development approval processes in Victoria: (i) VicSmart and (ii) standardised development assessment (DELWP, 2019a). VicSmart enables a limited range of low impact development types on land in selected overlays to be fast-tracked through a 10 day approval process such as standardised rainwater tanks. Whereas the standard planning permit process includes a notification period for public comments and referrals to other departments for statutory requirements or for additional expertise in the assessment. When a development is granted consent, a planning permit is issued to allow use and/or development of land subject to conditions. The conditions must be followed by the developer for the works to be authorised, including a building permit where necessary, and construction works are either certified by local government or private certifiers (DELWP, 2019b).

In most cases standard planning permit assessments are undertaken by local government and by DELWP when they have state significance. Application referrals are made to local government engineering departments as well as external authorities such as water utilities, for comments and development conditions (LG, 13 June, 2019).

4.2.3. Infrastructure (Physical, knowledge and financial)

Historically, the Melbourne stormwater landscape has been shaped by a centralised management system that drains stormwater away to large constructed wetlands to reduce pollutant loads (RossRakesh, Francey, & Chesterfield, 2006). These schemes have an end-of-pipe approach using a regional scale treatment train including traps for litter and sediment ponds. Stormwater within centralised systems is released into receiving water bodies including Port Phillip Bay (DELWP, 2018a), which is an important recreational swimming area. Poor stormwater quality therefore is a major concern to the city's liveability and economy. Increasingly, WSUD and IWM initiatives are being adopted across Greater Metropolitan Melbourne, however, the extent of these measures and their functionality are questionable (Williams, 2017). Some local governments such as the CoM have mapped assets on their website to promote government led and exemplary projects (City of Melbourne, n.d.). However, no comprehensive database of assets exists on privately owned land because they are too difficult to track and to ensure that they function satisfactorily (WR, 12 June, 2019).

The majority of interview responses indicated the important role that Melbourne universities and professional organisations play in promoting awareness and advocacy of stormwater issues, technologies and practice amongst industry professionals through training, conferences, research partnerships and online channels, including the CRC Water Sensitive Cities, Clearwater, Stormwater Australia, Vic Stormwater, Australian Green Building Council, and the Australian Water Association. In addition, the role of local governments providing initiatives to promote sustainable stormwater management outcomes. Such as CoM's demonstration green infrastructure projects including Green Your Laneway and Green Our Rooftop (LG, 14 June, 2019), and the CoPP's collaboration and promotion of the Inner City Melbourne Action Plan and its Model WSUD Guidelines (LG, 13 June, 2019).

Financing for stormwater projects varies depending upon the responsible authority and available resources. At a local government level, this can be achieved through their budget set by local land rates (i.e. taxes), as well as Developer Contribution Plans and Infrastructure Contribution Plans (DELWP, 2018b). However, recovering costs of stormwater infrastructure for redevelopments in established areas is identified as more difficult. Other government agencies also provide funds, such as Melbourne Water's Living Rivers Program (Melbourne Water, 2019) which provides financial assistance to local governments in Melbourne to implement stormwater quality improvement works, seeking to embed IWM and WSUD into standard practice.

4.3. Niche Emergence (Micro)

Two empirical case studies, the Inkerman Oasis and Fishermans Bend illustrate WSUD as a niche experiencing challenges in their development. Each case study is described in terms of their development history and actors, WSUD innovations, instruments and challenges. Although stormwater management is the focus of this thesis, its management in both case studies forms part of the IWM system – and for this reason aspects of the IWM are also described. IWM refers to a collaborative approach to water cycle planning including sewerage management, water supply, stormwater management and water treatment with consideration of environmental, economic and social benefits (DELWP, 2018c).

4.3.1. Inkerman Oasis

The Inkerman Oasis residential project at the time of its design and completion in 2008 (occupied in 2003), represented a significant contribution to WSUD, IWM and for delivering other environmentally sustainable outcomes (Aspin, 2007; Farrelly & Davis, 2009). It was led by an ambitious vision by the City of Port Phillip (CoPP) which sought to be a sustainability leader. In the early stages of its master planning, institutional systems were in their infancy in guiding WSUD and IWM development. As such, the development is considered a pioneer in its approach (Farrelly & Davis, 2009).

Project Overview

The 1.2 hectare development is located south of Melbourne's city centre in the suburb of St. Kilda, within the municipality of the CoPP (City of Port Phillip, 2008). The site comprises high-density residential mixed private and social housing. The development has a total of 262 units across six buildings. The development has ground floor retail and integrated art and public pedestrian access. The site and its surrounds are shown in Figure 4.3.

Formerly a municipal depot, it was investigated for renewal following local government amalgamations in the early 1990s for the purposes of social housing to be managed by CoPP (PP, 13 June, 2019). Direct ownership of the land by the CoPP gave the local government the impetus and the control over its development using an influential top-down approach which is perceived to be a key driver behind the achievement of exemplary sustainable design.

Early in the site's development, a project steering group was formed to assist the preparation of a master plan which took 4.5 years to complete (Farrelly & Davis, 2009). The steering group comprised representatives from CoPP, the State Government's development arm, the Urban Land Corporation (ULC) as an advisor as well as consultants such as Ecumenical Housing Inc to assist with social housing, and Architects Williams & Boag for their concept design services (City of Port Phillip, 2008). A carefully constructed master plan required the delivery of social housing, high quality urban design with integrated art, and environmentally sustainable design features (Farrelly & Davis, 2009). Due to costs, including remediation of the land, scale of development and the delivery of the masterplan's requirements, the CoPP entered a public-private partnership with Inkerman Developments Pty Ltd. The arrangement meant that, in meeting the master plan requirements as a financial incentive, the developer could deliver remaining units as private housing (LG, 3 June, 2019).

In the early 2000s, the site's remediation work was completed, the Department of Infrastructure approved the site's rezoning and a planning permit for construction was issued (Aspin, 2007). Planning assessment and referral involved several authorities including SEW, Melbourne Water and the Environment Protection Authority.

Construction for the project was staged across the site, with first resident occupations in 2003. Key actors in this project according to their level of governance is illustrated in Figure 4.4. The involvement of actors across the time frame of the project, this being from planning stages to end use management is illustrated in Figure 4.5.

Figure 4.3 Inkerman Oasis Development. Image adapted from Salvisberg (2019) and Google Maps, 2019 (https://www.google.com/maps)

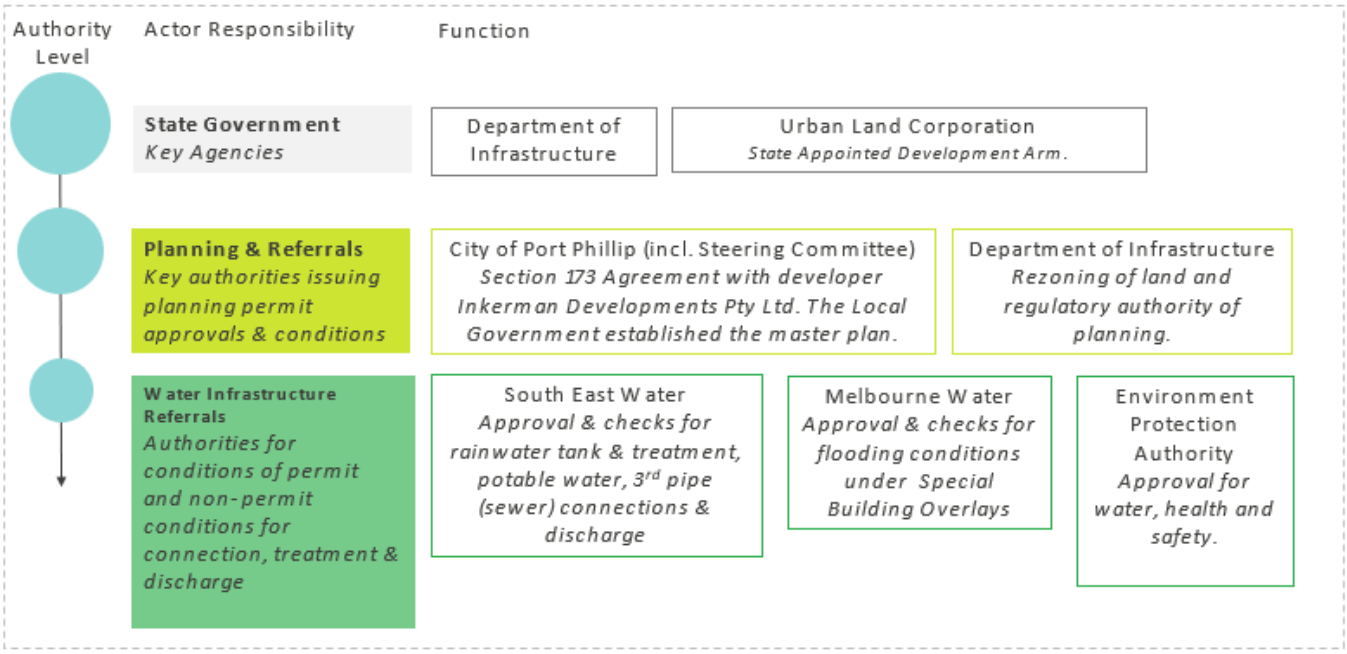

Figure 4.4 Inkerman Oasis Project Actor Hierarchy.

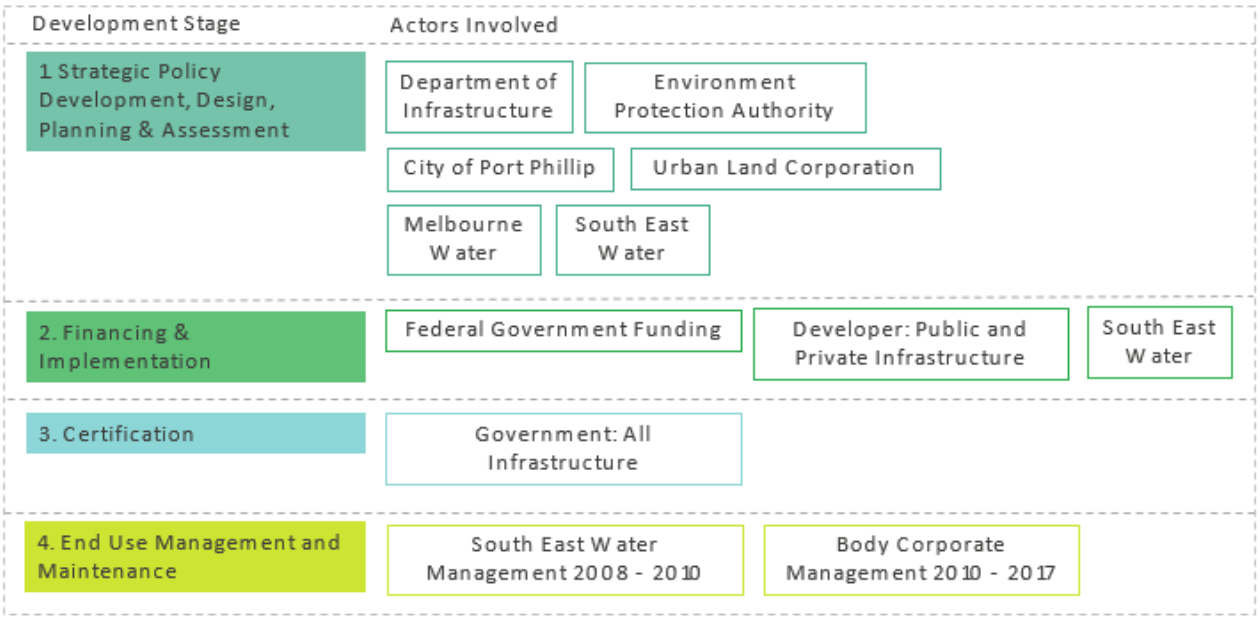

Figure 4.5: Inkerman Oasis Project Actor Involvement.

Innovations, Instruments and Challenges

Most of the site experiences flood risk which presented an opportunity to provide stormwater interventions (PP, 14 June, 2019). A combined greywater and stormwater recycling system design was intended for dual flush toilets and landscape irrigation on the site, which was to be the first of its kind in Victoria for a decentralised system in higher density housing. For its innovation, it received Federal Government grant funding and SEW became involved with the development in 2003 for research opportunities (Farrelly & Davis, 2009).

IWM Scheme

The final design of the combined stormwater and greywater system resulted in a different outcome to the one intended (City of Port Phillip, 2008). Originally, the stormwater and greywater systems were to be closed loop systems, where peak stormwater flows would be captured and treated with greywater though UV and chlorine processes for reuse in the development's dual flush toilets (Farrelly & Davis, 2009). The scheme was expected to reduce on-site potable water consumption by 40% in the summer months. However, SEW in their testing of the design, determined that treating stormwater together with greywater would dilute biological activity and result in excess reusable water. As a result, the greywater system was realised without the inclusion of stormwater. The greywater system was operationalised with information signage, guidance and glass domes to raise community awareness of the approach. The stormwater system was redesigned to capture rainwater from the building roofs and at ground level to pass through primary treatment via gross pollutant traps and biological filtration (City of Port Phillip, 2008):

- The biological filtration was provided by wetlands with a soil- gravel medium and absorption by native wetland plants to remove particles and nutrients. It covers most of the site measuring over 400m² providing both aesthetic landscaping and functionality.
- Stormwater not absorbed or retained by the wetland was discharged into the conventional stormwater system as partially cleaned. During the stormwater system's design, it was estimated that it would reduce bulk of gross pollutants and 14 tonnes per year of nitrogen and phosphates on the site before discharge to Port Phillip Bay.

Planning Instruments

In the instrument mapping for the project, formal and informal instruments were identified as important for the realisation of WSUD in the project. Important formal instruments included a Section 173 Agreement under the *Environment and Planning Act 1987* (vic) between CoP and Ecumenical Housing Inc (EHI). This agreement formed a binding contract for the developer to deliver the design requirements outlined by the master plan, in which most parts were delivered (PP, 14 June, 2019). As a social housing project, the direction for the inclusion of sustainable design standards were established by the *City of Port Phillip Housing Strategy 1997* (City of Port Phillip, 2005) including efficiency of water sources where possible.

Informal instruments through collaborative partnerships, research and sponsorship between the CoPP, SEW and the developer assisted the testing of the innovative greywater and stormwater system for the site, including the installation of educational signage to raise community awareness about the recycling scheme (Farrelly & Davis, 2009). Table 4.2 provides examples of local planning instruments identified as relevant to the project from interviews. In addition, instruments identified from the document review that may have applied to the project. Instruments have been included from late 1990s until 2003, when the first residential occupations begun. Construction was completed in 2008. The instruments listed are not an exhaustive list. The instrument map is available in Appendix C.

Table 4-2: Summary of Inkerman Oasis Local Planning Instruments

Instrument Type				Examples
	Local Mandates	Strategy	Water: i.e. Actions and targets to manage water resources.	***Water Management Local Action Plan 2003 - 2005:*** A strategic document that provides the context for water management practices within council operations and the Port Phillip community (Port Phillip Council, 2010).
			Climate Adaption: i.e. actions to address impacts.	***City of Port Phillip Housing Strategy 1997:*** Under the community housing section, strategy 6.3.10 seeks for the inclusion of sustainable design principles in Council's community housing program (City of Port Phillip, 2005).
			Strategic Council Plan: i.e. whole of Municipal priorities and actions	***Corporate Plan 2002 – 2006:*** Outlines the council's goals, corporate objectives and strategies. The link between service and sustainability are within the four pillars – Environmental Responsibility, Economic Viability, Cultural Vitality & Social Equity are central (City of Port Phillip, 2005).
		Planning Schemes	Contract: i.e. Municipal requirements over a precinct, to be fulfilled by land developers	***Section 173 Agreement (Planning and Environment Act 1987):*** The master plan for the site was as an agreement and locked in by way of an encumbrance on the title (Aspin, 2007).
	Informal	Incentive	Sponsors: i.e. Financial partners to deliver WSUD measures.	Partnership with SEW to develop greywater innovations (Farrelly & Davis, 2009).
		Public Relations	Collaborative Research: i.e. cooperate in opportunities to drive WSUD measures.	SEW testing and development of the greywater reuse system (Farrelly & Davis, 2009).

IWM Challenges

As an early pioneer of a decentralised greywater system, the development experienced several technical and administrative challenges in its implementation, specifically in relation to the greywater component (Farrelly & Davis, 2009). This was due to a lack of clear guidelines and regulatory approvals processes, where confusion of requirements resulted in much of the system being built before approval for works was granted. Retrospectively arrangements were made to meet requirements, SEW was contracted to monitor the system for the first six years and State Government authorities including the Environment Protection Authority gave their written consent for operation with conditions.

Despite being praised as being an innovative project at its time, the initiatives have since been turned off and disconnected. The stormwater system components along with the greywater recycling and dual flush toilets system were maintained by SEW until 2010, after which the development's body corporate took responsibility (Farrelly & Davis, 2009). Maintenance of WSUD and IWM systems is a key challenge to their optimal functioning which was experienced by this development (McGushin, 2017), particularly with the 'out-of-sight' nature of the infrastructure reducing visibility of cleaning issues but also a lack of accountability of maintenance operations which can be independently decided after realisation. For apartment building managers maintenance of systems is reported as poor, which could be attributed to the unfamiliarity of the infrastructure and a desire to keep rates low, which in the case of the Inkerman Oasis project may be the reason that the technology was turned off altogether.

4.3.2. Fishermans Bend

Fishermans Bend is an iconic renewal project led by a visionary plan to the year 2050. The project is currently the largest precinct renewal in Australia, seeking to transform 480 hectares of industrial and warehousing area located south of Melbourne's city centre to a mixed use and residential apartment community (DELWP, 2019e). The State Government's vision is to deliver '*a thriving place that is a leading example for environmental sustainability, liveability, connectivity, diversity and innovation*' (p18) and its sustainability approach is based on Australia's best practice Green Star Communities tool by the Australian Green Building Council.

The *Fishermans Bend Framework (2018)* is a long term strategic plan to transform the area to provide approximately homes to 80,000 residents and up to 60,000 jobs (State Government of Victoria, 2019). Discussion for the detailed planning that supports the plan's vision is ongoing, with the CoPP and the CoM taking part in this process as the respective local government areas (City of Port Phillip, n.d.-a). As a current and ongoing infill project, it provides the possibility to review how WSUD as a niche has progressed since the early pioneer projects like Inkerman Oasis – however despite the promising visions for the area, challenges are equally matched.

Project Overview

The Fishermans Bend urban renewal area is also south of Melbourne's city centre and is nestled between the Yarra River and Port Phillip Bay, and comprises five precincts illustrated in Figure 4.6. The area currently supports 13,000 jobs (DELWP, 2019b). The Montague, Lorimer, Sandridge and Wirraway precincts since 2012 have been zoned to allow high density residential development and are the Employment Precinct has retained its industrial use and zoning. The Employment Precinct and Lorimer precincts are located within the CoM, and Montague, Sandridge and Wirraway are in the CoPP. A field trip to the site identifies existing water bodies and green space in the renewal area, as well early residential construction sites, surrounded by established and well performing commercial and industry land uses.

For many years, the area has supported a range of employment uses including industrial and port services, flourishing as an attractive business location in proximity to the city centre (State Government of Victoria, 2019). In 2012, the State Government's Minister for Planning identified Fishermans Bend as a renewal area of state significance and rezoned land to enable high density residential development (City of Port Phillip, n.d.-a).

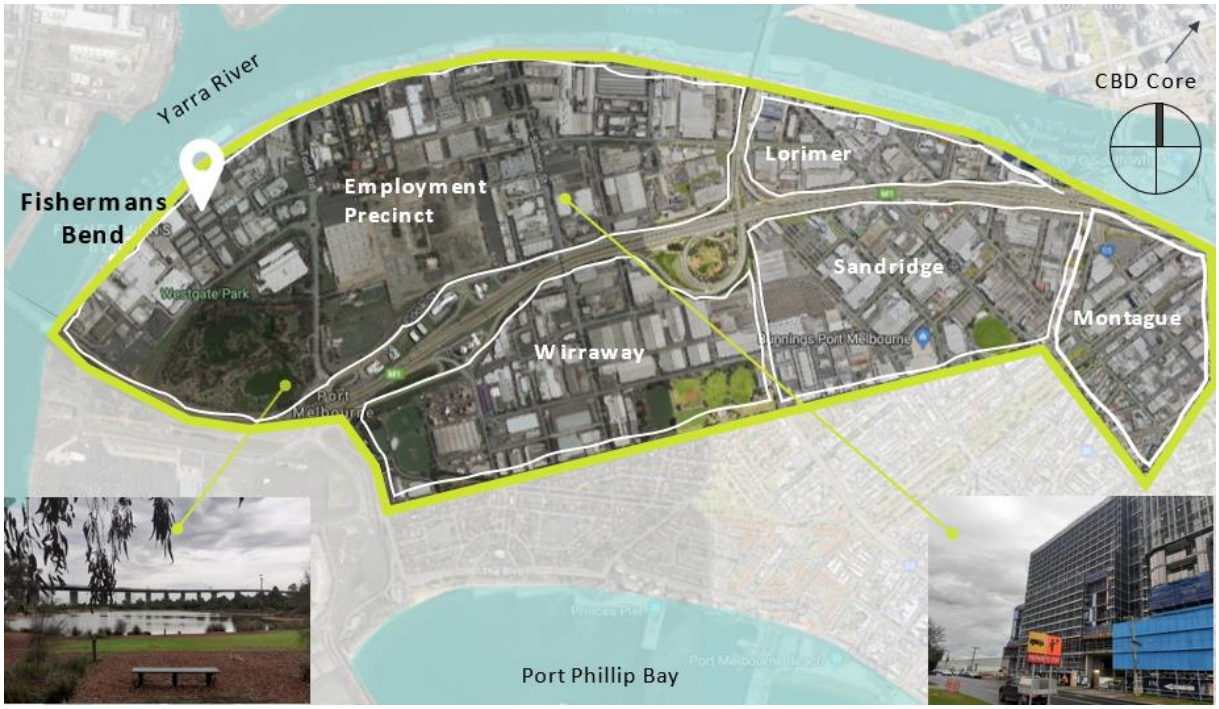

Figure 4.6: Fishermans Bend Development. Image adapted from Salvisberg (2019) and Google Maps, 2019 (https://www.google.com/maps)

The rezoning is widely criticised for occurring prematurely before State Government purchasing of land assets to deliver important public infrastructure projects (Lavelle, 2018). The decision happened 'overnight' without local government and landowners being prepared for the changes (LG, 13 June, 2019). As a result, the land value of the area has dramatically increased and has caused significant developer speculation (Vedelago & Houston, 2018).

Since the rezoning, new State Government leadership has been working to address strategic planning issues for Fishermans Bend which has led to the release, preparation and establishment of several authorised committees and bodies (City of Port Phillip, n.d.-a). A revised vision for the renewal area was released in 2016, and, most recently, the Fishermans Bend Development Board released strategic strategies including: *Fishermans Ben*d Vision 2016; A Community Infrastructure Strategy 2017 and Fishermans Bend Framework 2018 to 2050 (State Government of Victoria, 2019).

As planning controls for the area are still being formed, in February 2018, 26 early development proposal applications received by the State Government were frozen until the finalisation of site planning controls (Carey, 2018). A key topic in the review of planning controls relates to building height reduction, which could reduce financial feasibility of proposals. However, commentators express even more concern for the delivery of sufficient public infrastructure given minimal public land holdings in the area.

The renewal area is located close to where the Yarra River discharges into Port Phillip Bay, which makes the land vulnerable to inundation in tidal events, as well as regular flooding due to underground drainage constraints (DELWP, 2019e). These issues combined with proposed density have significant implications for water infrastructure planning.

Key actors in this project according to their level of governance are illustrated in Figure 4.7. The involvement of actors across the time frame of the project, this being from planning stages to end use management is illustrated in Figure 4.8.

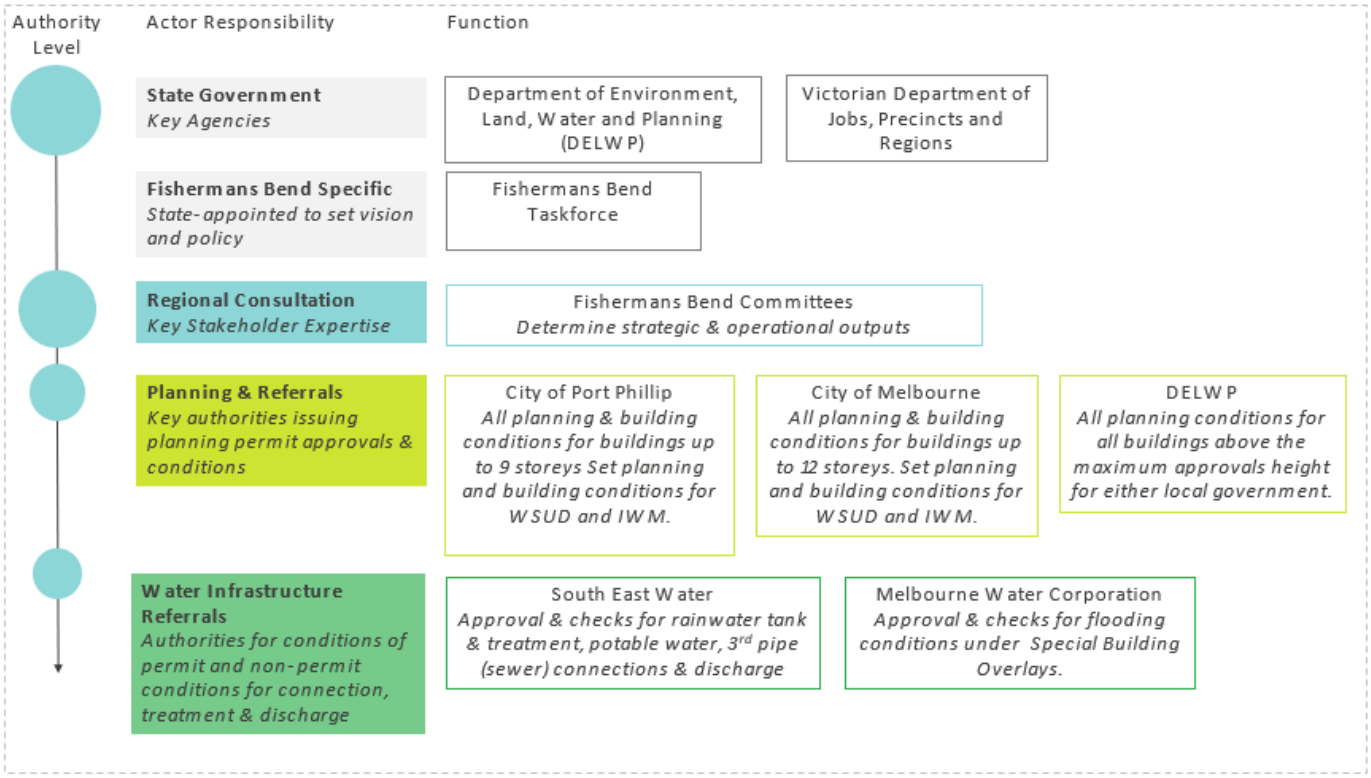

Figure 4.7: Fishermans Bend project actor governance hierarchy (informed by WR, 12 June, 2019)

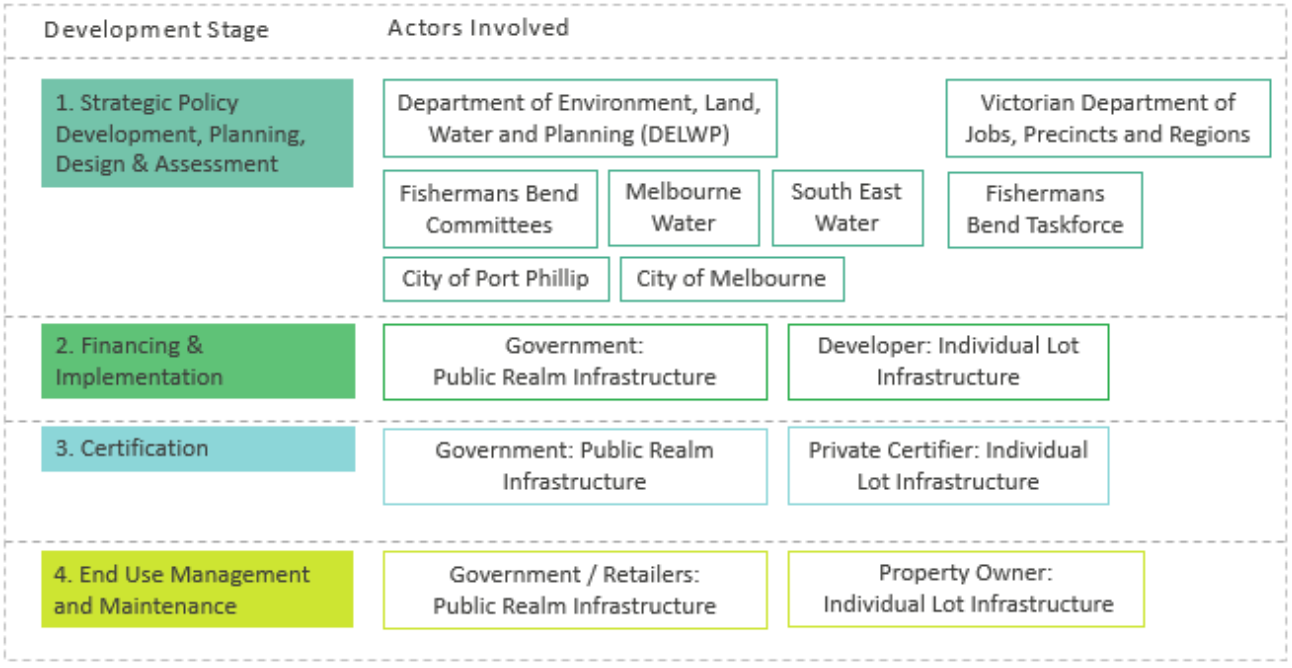

Figure 4.8 Fishermans Bend project actor involvement

Innovations, Instruments and Challenges

In addition to stormwater flooding and tidal inundation vulnerabilities of Fishermans Bend, due to past industrial land uses there is also groundwater contamination (DELWP, 2019e). For stormwater management, these issues present significant challenges, which planning is currently trying to address to not only deliver an exemplary environmental outcome, but also one that is safe for human habitation and can be achieved in area that is mostly privately-owned land. An IWM scheme is being progressed by SEW for the area.

IWM Scheme

The *Fishermans Bend Framework 2018* is structured around eight sustainability goals which are given effect through planning controls in the CoPP and CoM Planning Schemes (DELWP, 2019e). The goals (4) a climate resilient community; (5) a water sensitive community and (6) a biodiverse community are promising visions for Fishermans Bend's future development of BG Infrastructure. The water sensitive community goal seeks to reduce the reliance on potable water to less than 100 litres per person per day, and deliver (DELWP, 2019e):

- *SEW Precinct -Wide Water Recycling Plant:* The facility is planned to supply Class A recycled water via a third pipe to all new buildings, and providing this connection is mandated within building development approval 'Conditions of Connection' (WR, 12 June, 2019). The facility is considered to provide a lower cost than smaller building scale systems and seeks to reduce potable water supplies for toilet flushing, laundry and garden watering.
- *Rainwater tank detention and retention within all buildings:* All new buildings will be required to incorporate best-practice water-efficient fixtures and rainwater tanks for flood mitigation. Incorporation of smart grid technology in buildings is promoted to regulate water detention levels and required recycled water requirements.
- *WSUD landscaping:* Streetscape and open space mitigation measures to improve water quality and manage flooding.

Planning Instruments

The instrument mapping for the project identified a variety of informal and formal instruments related to BG Infrastructure planning for CoM and CoPP. Recent amendments have been made to the Planning Schemes of both Councils to reflect requirements within the *Fishermans Bend Framework 2018*. These requirements include third pipe recycled water use connections, addressing heat island impacts by requiring at least 70 % of the total site area to include vegetation, green roofs and water bodies and, for all landscaping to integrate best practice WSUD (Melbourne Planning Scheme, 2019). Interview respondents indicated that buildings above eight storeys in height would be assessed by the State Government, but would also be referred to local government for detailed comments such as local WSUD requirements (LG, 13 June, 2019). As a result of discretion that occurs in a development decision, it was indicated that this may impact the detail of requirements between different approval authorities in addressing the local based strategies.

A few informal incentive instruments were discovered in the document review of local planning instruments that financially incentivise WSUD approaches, including the CoPP's *Sustainable Design Strategy 2011*, which waivers planning permit fees for rainwater tanks and greywater systems. Another example is the CoM's *Design and Development Overlay 10*, which allows floor area uplift in exchange for the provision of public benefits such as public open space (LG, 14 June, 2019). However, it is unknown whether these incentives apply to Fishermans Bend. There were many initiatives for public relations promoted by the local governments ranging from WSUD technical guides, demonstration projects and education forums. Table 4.3 provides examples of local planning instruments identified for Fishermans Bend from the CoM and CoPP, through interview responses as well as a document review of other instruments that could apply to future developments in the precinct. The instruments listed are not an exhaustive list. The instrument map is available in Appendix D.

Table 4-3: Summary Fishermans Bend Local Planning

				Examples
Instrument Types	Local Mandates	Strategy	Greening of Public Spaces i.e. Design and management of public open spaces.	***Greening of Port Phillip – an Urban Forest Approach 2010:*** Provides the strategic framework and policy context for the development and management of trees, recognising trees cannot be managed in isolation from other elements of the urban environment (City of Port Phillip, 2010).
			Greening of Private Spaces i.e. Design of private open spaces.	***Green our City Strategic Action Plan – Vertical and Rooftop Greening Melbourne 2017 – 2021:*** A focus on facilitating green infrastructure in the private realm (City of Melbourne, n.d.-b).
			Municipal Strategic Statement: i.e. Key framework for land use and development, including zoning and priority actions.	***City of Melbourne Municipal Strategic Statement 2010:*** Key strategic planning, land use and development objectives for a municipality and includes strategies and actions. It provides the strategic basis for the application of local policies as well as zones and overlays. The CoM's Municipal Strategic Statement includes reference to vegetated rooftops as a method for increasing biodiversity in cities (City of Melbourne, 2010).
			Overlays i.e. Mapping of special features such as flooding, which is controlled by planning conditions and permits.	***VPP Clause 44.05 Special Building Overlay (SBO 2)*** planning scheme controls that identify areas prone to overland flooding to set appropriate conditions and floor levels (Melbourne Water, 2017).
			Precinct Planning i.e. Development standards for designated precincts.	***City of Melbourne's Clause 22.27 Fishermans Bend Urban Renewal Area Policy 2018:*** This policy is identical for CoPP. It includes controls to support objectives including: Creating a benchmark for sustainable and resilient urban transformation that supports water sensitive communities, to create resilience against the impacts of sea level rise and flooding from storm events (Melbourne Planning Scheme, 2019).
			Stormwater Management: i.e. development standards for design outcomes.	***- LPP Clause 22 Stormwater Management (Water Sensitive Urban Design) (2015)*** ***- LPP Clause 22.27 Fishermans Bend Urban Renewal Area Policy (2018)*** ***- LPP Clause 22.19 Energy, Water and Waste Efficiency (2013)*** ***- VPP Clause 53.18 Stormwater Management in Urban Development*** ***- VPP Clause 56.07 Integrated Water Management***
			Sustainable Development i.e. Development standards for design outcomes.	***City of Port Phillip's Clause 22.13*** Environmentally Sustainable Development 2015: Supports integrated water management in residential and non-residential buildings (Port Phillip Council, 2017).
	Informal	Incentives	Bonuses i.e. An additional allowance when WSUD measures are delivered.	***City of Melbourne's and Development Overlay 10:*** Allows floor area uplift in exchange for provision of public benefit including publicly accessible open space (DELWP, 2019g).
			Exemptions i.e. Removal of requirements when WSUD measures are delivered.	***City of Port Phillip's Sustainable Design Strategy 2011:*** Waives planning permit fees for rainwater tank and greywater systems (City of Port Phillip, 2011).
		Public Relations	Awareness i.e. Raise the profile of WSUD measures amongst citizens and professionals.	**Council Alliance for a Sustainable Built Environment (CASBE):** A collection of Victorian municipal governments working towards sustainable built environments (City of Port Phillip, 2011).

IWM Challenges

Challenges experienced by the urban renewal area are significant. These include:

- A lack of government-owned land to cost effectively realise IWM infrastructure as a result of premature rezoning;
- Mitigating flooding impacts from riverine, groundwater and sea-level inundation, and impacts from contaminated groundwater which limits underground works;
- Integration of requirements for planning between two local governments, State Government, water retailers and authorities to realise effective outcomes; and
- Effective control and on the implementation of IWM infrastructure for optimal operation, which places a lot of responsibility of maintenance on landowners to understand the infrastructure and ensure its function.

As a key facilitator of the IWM initiatives for Fishermans Bend, the utility, SEW, has undertaken planning instrument reviews to improve precinct IWM outcomes. Some key findings from their review include (Ramanchandran, 2019):

- Concerns on the lack of control over quality construction and regular maintenance of IWM assets with a lack of clarity of roles and responsibilities for the checks on assets and their long-term maintenance and functionality.
- Differences in assessments and requirements for IWM between authorities as well as 'variable and sometimes contradictory' benchmark tools (e.g. MUSIC, STORM, GreenStar), which enables developers to seek minimal compliance.
- Unclear language in the descriptions for implementation of rainwater tanks and 3rd pipe connections, such as effective volumes and requirements for applications to identify the intended treatment and use of harvested rainwater.
- Unclear linking between the four focus areas underpinning a WSC (i.e. stormwater retention and detention, alternative water, water quality and urban cooling). This, they identify as an example where there are unclear planning levers and targets to achieve outcomes. Such as a limited integration of requirements between WSUD and urban greening to achieve urban cooling outcomes.

4.3.3. Case Study Reflections

The case studies highlight some noteworthy differences in the strengths and weaknesses experienced in the planning of IWM outcomes:

Inkerman Oasis

Strengths: Land ownership and strong leadership by CoPP making the delivery of IWM mandatory for the developer through an articulated masterplan. The extensive strategic planning informing the masterplan was successful in 'locking-in' key deliverables, notwithstanding technical difficulties experienced with the greywater and stormwater system.

Weaknesses: The early development of planning controls for IWM systems were still in their infancy, which contributed to confusion on roles, responsibilities and requirements to realise the system. The complexity of the system and its high maintenance regime without enforcing checks on its operation, led to system failure.

Fishermans Bend

Strengths: Increased knowledge of IWM systems and support for WSUD across planning instruments and informal initiatives, particularly the embedding of water sensitive requirements in local Planning Schemes to achieve WSC outcomes.

Weakness: A lack of government commitment in staging the land zoning to feasibly acquire important sites to realise IWM infrastructure, to complete detailed planning to realise the master planned vision for the site and to address physical challenges of flooding. A lack of integration between policies, for example the prescriptive requirements in the Local Planning Scheme do not make strong links between green space and WSUD potential. A lack of clear responsibilities in the construction checks, maintenance and monitoring of future assets in IWM is also a concern.

4.4. Chapter Summary

This chapter presented a background of Melbourne's stormwater landscape. The case studies present two examples of BG Infrastructure interventions for former brownfield sites for infill higher density residential use. Both projects have design visions to achieve exemplary outcomes in IWM including stormwater.

The governance and case study descriptions presented provide a background context for a closer investigation of persisting barriers and opportunistic drivers identified in practitioner interview responses, addressed in chapter 5. This exploration seeks to identify the influence of local planning instruments in realising BG Infrastructure.

5. Results

This chapter presents the results of this thesis, including findings from (9) practitioner interviews and (30) online questionnaire responses about the influence of local planning instruments as well as barriers and drivers for Water Sensitive Urban Design (WSUD) in Melbourne, Australia. Findings from interview responses are presented according to the conceptual framework of barriers and drivers outlined in the literature review. Economic, environmental, institutional, social and technical aspects represent different factors influencing the effectiveness of planning instruments. Interview findings are outlined and discussed. Findings from the questionnaire are used to quantify interview responses with a larger and more representative number of practitioners. The chapter concludes with a discussion on the study's findings and addresses the key research questions.

5.1. Identifying Barriers and Drivers for Planning Instruments

Among the semi-structured interviews, there was a mixed representation of WSUD practitioners with two private practitioners, four local government officers from the City of Melbourne (CoM) and City of Port Phillip (CoPP) and three water retailers from South East Water (see Table 5.1 for an overview).

All participants, identified as having knowledge of the Fishermans Bend (FB) case study, recognised it as an iconic current project in Melbourne. Seven participants had current and direct involvement in the Fishermans Bend development including participation in IWM Forums influencing the development's master planning, selection of IWM technologies and policy implementation.

For the Inkermann Oasis (IO) case study, five participants identified as having knowledge about the project, while only two interviewees had direct involvement in project management and coordination of master plans. This reflects the project's completion date in 2008, as well as difficulty in securing further participants for this project. Interviewees with knowledge of the project identified it as a well-known pioneer project for WSUD.

5.1.1. Planning Instruments

Chapter 4 presented some local planning instruments that have relevance to the case study projects. Key findings from interview responses related to the mapping of local planning instruments identified for CoM and CoPP are outlined below.

- *Formal instruments* (i.e. local mandates) comprise Strategies and Planning Schemes. Identified strategies related to BG Infrastructure include Strategic Council Plans, Greening of Public Spaces, Greening of Private Spaces, Water Plans and Climate Adaptation. Planning Scheme instruments relate to Municipal Strategic Statements, Contract Agreements, Overlays, Precinct Planning, Sustainable Development and Stormwater Management.
- *Informal instruments* comprise Incentives and Public Relations. Incentives related to BG Infrastructure identified include Bonuses, Exemptions and Sponsors. Public Relations included initiatives for Awareness, Collaborative Research and Best Practice Guidelines.

In the case study projects, local planning instruments were important for realising IWM outcomes. In the Inkerman Oasis development, a contract agreement was critical in securing the delivery of outcomes, notwithstanding technical difficulties faced. In the Fishermans Bend project, the implementation of

Table 5-1: Summary of practitioner interview data including representation, method of interview and corresponding case study knowledge.

	Expertise	Representation	Interview Method	Case Study Knowledge
1	Stormwater Drainage Engineer	Local Government (LG)	In-person	FB + IO
2	Integrated Water Management	Water Retailer (WR)	In-person	FB
3	Technical Management	Water Retailer (WR)	In-person	FB + IO
4	Integrated Water Engineer	Water Retailer (WR)	In-person	FB
5	Water Cycles Management	Local Government (LG)	In-person	FB + IO
6	Environmental Scientist	Private Practitioner (PP)	In-person	FB + IO
7	Sustainability – Stormwater	Local Government (LG)	In-person	FB
8	Project Housing Coordinator – Environmental sustainability agenda	Local Government (LG)	Phone interview	IO
9	Principal Architect – Environmental sustainability agenda	Private Practitioner (PP)	In-person	IO

prescriptive measures in the Planning Schemes of both CoM and CoPP are important for tying the IWM vision of the precinct the local assessment of development proposals.

5.2. Barriers and Drivers

During the interviews, respondents were provided with a list of twenty-six factors identified from literature that represent barriers and drivers for realising BG Infrastructure, categorised according economic, environmental, institutional, social and technical aspects. Interview respondents raised additional factors in their responses. Appendix E provides the complete list of factors. Responses identified more factors as barriers (19) than drivers (8).

Barriers

Table 5.2 outlines 19 factors identified as barriers by interview responses across all themes. Each sub-category is addressed according to key points raised by respondents.

Economic

The *City Government's Budget* relates to limited, restricted and silo resourcing of financial resources of different departments. Freezing of Municipality rates (i.e. land taxes) has reduced available spending to hire more staff to control the quality of WSUD assets as well as undertaking WSUD public asset projects (WR, 12 June, 2019). The rezoning of land in the case of the Fishermans Bend project exponentially raised its value and now that land is has become expensive, it has questioned the business case for undertaking public asset works (LG, 13 June, 2019).

Investment costs relates to significant financial resources needed for technology investment and construction, including land value, materials and labour. Costs of WSUD technologies can be a significant financial barrier for on-site stormwater management for small-scale developers, when the perceived benefits are considered less than investment value (PP, 14 June, 2019). Moreover, investment costs for sustainable outcomes are not considered over a long-term view, which can reduce support for WSUD uptake (WR, 12 June, 2019)

Maintenance cost relates to the planning of the WSUD asset accounting for the ongoing and long-term financing of maintenance for optimum use. There is a barrier to their optimal functioning, as toften there is more pressure on maintaining assets that are already realised than building them (WR, 12 June, 2019). This occurs as the budget allocations are separate for the design and building of assets, where budgets usually remain unchanged even with a higher number of assets. Consequently, budget resources are thinly stretched to maintain assets.

Environmental

Pollution relates to the legacy of contaminants from previous land use and mitigation need to improve water quality in redevelopment. For

Table 5-2: Summary of barriers identified by practitioner interviews.

Economic	Environmental	Institutional	Social	Technical
• Limited City Government Budget • High Investment Cost • High Maintenance Cost	• Legacy of Pollution	• Low Commitment • Limited Entrepreneurial Activity • Low Expertise • Limited Knowledge Transfer • Lacking Policy Integration • Lacking Political Will (top-down) • Low Priority • Low Private Sector Interest • Lengthy Procedure Time • Unclear Responsibility • Silo Resourcing	• Low Awareness of Benefits • Low Environmental Stewardship	• Limited System Functionality • Replication Issues

this reason the implementation of WSUD is problematic for Fishermans Bend as the water table is very close to ground level which has contaminants from prior industrial uses in the precinct (WR, 12 June, 2019). Contaminated water needs to be carefully treated in sealed tanks and WSUD measures will need to be kept separate from contaminants rising to ground level.

Institutional

Low C*ommitment* to strategic planning was evident in the premature rezoning of Fishermans Bend before a renewal vision and support mechanisms were established. It compromised the ability for carefully staged planning of WSUD assets as well as delivery of significant infrastructure (WR, 12 June, 2019).

Entrepreneurial activity to trial innovative approaches is often resisted because of perceived risk. This creates a barrier for WSUD implementation which was identified even for leading municipalities in this approach (LG, 14 June, 2019).

A lack of *Expertise* relates to limited knowledge of WSUD and its implementation requirements which can impact the optimal operation of WSUD measures (WR, 12 June, 2019). This was identified as a barrier for development proposals in Fishermans Bend, when final assessment decisions for large developments occur at State Government level, and assessing officers change detailed WSUD advice according to their discretion.

Knowledge Transfer relates to a lack of information sharing between administrative professionals to support technology adoption. For example, between asset managers to match modelling, planning and legislative controls for water management (WR, 12 June, 2019). Moreover, the insufficient knowledge about WSUD functions and proper cleaning by maintenance teams, has led to WSUD system failure (LG, 11 June, 2019). Changes in land ownership also results in loss of information for the new owners about stormwater assets on the land. Especially the operation and maintenance of the assets is not clear and the new owners end up removing them (PP, 14 June, 2019). This was the experience in the Inkerman Oasis development, when responsibility for assets was transferred to the body corporate, and maintenance was not continued (McGushin, 2017).

Policy Integration relates to inconsistent policy and plan making which is responsive and reciprocal. There are a host of related WSUD strategies and policies from national to local level. However, the requirements are critiqued for being partial, not addressing each other and having conflicts in their implementation (WR, 12 June, 2019). In the Fishermans Bend development this was problematic as indicated by SEW's review of instruments (Ramanchandran, 2019) particularly when trying to achieve sustainable outcomes and multi-benefits of WSUD. Balancing competing priorities, multiple actors and addressing maintenance and operations is also a challenge, especially as traditional planning instruments are limited by their short-term trajectory and do not often capture small scale developments (LG, 14 June, 2019). These developments are occurring across the city and are incrementally but radically changing the permeability of urban areas.

A lack of *Political Will (top-down) and* prioritisation of WSUD in development outcomes was identified for the Australian context, where federal politics have reduced the climate change agenda, which has flow-on effects to other government levels (LG, 14 June, 2019). So that if local governments want to push WSUD and sustainable outcomes, they may have less support to do so.

A lack of *Priority* is a barrier for WSUD when it competed with other performance goals and deliverables. In the Fishermans Bend development, building heights are a contentious topic with the community, so this has been given more priority in the area's current discussions (WR, 12 June, 2019). In the Inkerman Oasis development, priorities for meeting public health requirements were a barrier to pushing the innovative scope of the project (LG, 14 June, 2019).

Private Sector Influence relates to the authority that developers have in built form outcomes that can undermine the optimal delivery and visions of WSUD. For example in the case of Fishermans Bend, other large renewal precincts developing in Greater Metropolitan Melbourne, including Arden McCauley and Docklands give developers options on their location and more power to negotiate their development outcomes, which could undermine the delivery of IWM outcomes if they are not mandated (LG, 13 June, 2019).

Procedure Time relates to lengthy administrative processes to approve WSUD, where delays in assessing applications are a barrier in losing confidence, good will and patience of the developer which can compromise preferred WSUD outcomes (LG, 14 June, 2019).

Responsibility relates to unclear ongoing management of assets which compromises their optimum working condition. Practitioners recognise that maintenance of WSUD measures is inadequate, which is related to the difficultly of compliance checks during construction, as it is often the responsibility of private certifiers (WR, 12 June, 2019). As a result, municipalities do not know whether a stormwater management plan was administered successfully, which also limits the possibility to learn from its implementation. Further, that often municipality engineers have a closed mindset about WSUD asset design because of maintenance responsibility (LG, 14 June, 2019).

Silo Resourcing relates to the isolation of organisational and resource flows, where municipality departments are often established with separate objectives and budgets, and therefore joint projects and outcomes are discouraged (LG, 11 June, 2019).

Social

Lack of *Awareness* relates to limited knowledge of WSUD and its implementation benefits. Practitioners identified that general public knowledge of WSUD benefits is poor and that there is a lack of education and promotion of measures outside of the industry (LG, 14 June, 2019). This discourages the incorporation of WSUD in development proposals which is a preferred approach, compared to reliance on planning permits to condition an 'add on' WSUD feature (DELWP, 2018b).

A lack of *Environmental Stewardship* relates to low care of ecosystem services and their functioning. Practitioners identify that there is a lack of stewardship as developers resist investment in stormwater management, even if they are informed about its improved environmental outcomes, because it costs time and money (PP, 14 June 2019).

Technical

Reduced System Functionality relates to the inability of WSUD to operate as intended which can be the result of poor design and compliance checks (WR, 12 June, 2019). Recent development approvals in the Fishermans Bend precinct for example were mandated to install rainwater tanks, however the pumps and volumes have not been paired to allow for regular use, which limits the functionality of the system.

Replication relates to issues with copying WSUD design which does not response to unique site conditions and a result fail (LG, 11 June, 2019). Place based approaches are particularly important as natural systems cannot be replicated, and so standard developer checklists are insufficient.

Observations on Barriers

Although practitioners' responses agree that WSUD is important, they identify that the value of WSUD measures is often compromised due to undercurrent institutional flaws in:

- Design and implementation which is often not tailored to unique site conditions, as a result of lacking expertise and a transfer of knowledge during the planning phase, leading to asset failure;
- budget allocations which are limited to optimally realise assets as well as their maintenance;
- responsibility with limited accountability of whether assets have been (a)realised on private land and (b) where they are located; and
- government leadership, testing and championing WSUD outcomes, which often falls behind other priorities in planning, such as developer investment, building heights and rezoning of land in the case of Fishermans Bend, or is avoided because of perceived risk.

The institutional flaws reflect the results of a 2011 OECD country study on obstacles for urban water governance, specifically ambiguous legislation, poor implementation, limited capacity at a local level, unclear roles and responsibilities and allocation of resources (Koop & van Leeuwen, 2017). Specific to planning instruments, interview responses also indicate that policy integration is a key issue, despite there being many WSUD strategies and policies available, as the instruments:

- often conflict one another with their requirements;
- have a short-term trajectory for the lifespan of WSUD measures;
- do not sufficiently support multi-benefit outcomes; and

- often smaller developments across the city are not required to include WSUD and collectively make a large impact in the reduction of permeable land in an urban setting.

Another key finding is the lack of public knowledge about the benefits of WSUD for environmental outcomes, and so developers resist the inclusion of WSUD. Knowledge also influences environmental stewardship and motivations to invest in best practice, as when there is a limited understanding of why ecosystem services are important, there is limited interest in why they should be protected.

Drivers

Table 5.3 outlines nine factors identified as drivers by interview responses across three themes, and below, each sub-category is addressed according to key points raised by respondents.

Environment

Climate Change relates to the promotion of adaption and mitigation measures to reduce climate disturbances. Urban heat and cooling are significant topics in the Australian community in the face of climate change, and so WSUD address this issue will drive more support (LG, 14 June, 2019).

Intervention for *Flood Risk* was an important driver for WSUD for the Inkerman Oasis and Fishermans Bend projects, both vulnerable to flooding. The Inkerman Oasis project designed WSUD measures as a wetland to respond to flood levels (PP, 14 June, 2019). And as the Fishermans Bend project has a high-water table and proximity to sea level, WSUD have been targeted to address associated flooding risks (WR, 12 June, 2019).

Multi-Benefits relates to the delivery of other aesthetic and functional outcomes with WSUD assets which can generate a positive community reception to measures (PP, 14 June, 2019). Stormwater treatment is still often not regarded by the community as an important resource. So generally WSUD strategies are more successfully promoted with synergistic benefits, such as urban cooling, as thermal comfort is a more relatable experience for Melbourne's community (LG, 14 June, 2019).

Institutional

Collaboration relates to beneficial cooperation in delivering joint outcomes, for example the resurfacing of a road together with WSUD is less wasteful in time and resources, and is more positively perceived by the community (LG, 11 June, 2019).

Entrepreneurial relates to innovative activity which can drive the adoption of WSUD, such as South East Water's development unit IOTA (WR, 12 June, 2019). IOTA has entered a space traditionally outside of their business model by developing 'Tank Talk' smart stormwater tanks, which can empty water. It is suggested that the role of IOTA could be extended to WSUD asset auditing on private and public land to alleviate responsibilities from local governments and private owners.

Political Will (top-down) relates to government support of WSUD, such as the recent commitment by State level planning to increase the agenda of sustainable stormwater management at a catchment level through IWM Forums (LG, 11 June, 2019). Also the critical driver of mandatory environmental targets which are recognised as being necessary for stormwater management so that developers must achieve outcomes (LG, 13 June, 2019). In the Inkerman Oasis project, top-down management and control of the project by the municipality, in partnership with a State governing arm, was key to progressing so many sustainable outcomes, including WSUD which was still in its early diffusion at the time of development (PP, 14 June, 2019).

Table 5-3: Summary of drivers identified by practitioner interviews.

Environment	Institutional	Social
• Climate Change Mitigation • Flood Risk Intervention • Delivery of Multi-Benefits	• Beneficial Collaboration • Entrepreneurial Activity • Supportive Political Will (top-down)	• Promote Awareness • Environmental Stewardship

Social
Awareness relates to knowledge of WSUD and its implementation benefits. Project champions are promoted for their role in elevating the priority of WSUD and educating others to strengthen commitment (LG, 14 June, 2019). These champions can be in the government or in the community. Further, learning from other case studies and international experiences helps to showcase possibilities and build business cases for new WSUD approaches (LG, 14 June, 2019). In the Fishermans Bend project practitioners have been researching international examples on built form such as the two-tiered flood building level adopted in HafenCity, Hamburg (WR, 12 June, 2019).

Environmental Stewardship relates to the care of ecosystem services and their functioning, which can be promoted through WSUD when they are designed in a way that allows the public to use a space, to be in contact with nature while at the same time limiting flood risk, as it creates a connection between the community and the natural environment (WR, 12 June, 2019). Moreover, it helps build a positive public image of stormwater management (LG, 14 June, 2019).

Observations on Drivers

Practitioners identify that one of the most significant opportunities for WSUD is greater public awareness of why measures are important for beneficial environmental outcomes. They argue that realising multi-benefits such as landscaping makes measures more 'sellable' to the community and increases environmental stewardship. Flood risk is also seen as an important driver at project level. Further, the promotion and delivery of urban cooling interventions, as heat is a significant topic in the Australian climate change debate, and a relatable experience for city dwellers. This highlights a negative perception or disinterest in stormwater management as an issue not worth prioritising by citizens. This is supported by other studies that identify resistance to BG Infrastructure when benefits are not measured as they are perceived as more expensive (Qiao et al., 2018; Wihlborg et al., 2019).

Political will with top-down prioritisation of measures through mandatory requirements is identified as necessary to realise outcomes, especially from the State Government level. Responses indicate that without a mandate there will be no impact, stressing a development culture that does not view or understand that WSUD benefits are important or worth prioritising. The development of IWM Forums for catchment level planning is viewed as a positive step towards mainstreaming WSUD practice, rather than at a project level basis where local governments need to fight for WSUD outcomes.

An interesting finding is the emerging role of water retailers in the space of innovation to meet customer water demands. South East Water has played an active role in the Inkerman Oasis project and is now continuing to develop innovative ideas for the Fishermans Bend project including the recycling water plant. Operating within a different business model, their role in WSUD was identified as one that could potentially extend to address institutional challenges in monitoring and maintenance of assets.

5.2.1. Recommended Instruments

Interview respondents were asked for their recommendations on how planning instruments can more effectively realise WSUD in response to barriers and drivers they identified. Responses comprised a mix of formal and informal instrument initiatives. Most recommendations relate to institutional challenges using formal instruments for reform, which indicates practitioners' preference for change in governing processes for WSUD with mandates. Table 5.4 outlines the respondents' suggestions according to theme, issue, response, planning instrument type and implementation. A summary of these answers is provided below.

Economic: To address a lack of financial resources in realising WSUD measures, informal instruments of campaigns and partnerships were suggested to engage the broader community in funding schemes for multi-benefit outcomes, as well as financial incentives, such as interest free loans.

Environment: To improve environmental stewardship in the management of WSUD measures, education is promoted as an informal measure to increase knowledge of shared health benefits of waterways and the community.

Institutional: Several suggestions were raised to address issues in policy integration, WSUD design, knowledge, maintenance, protection of green landscaping and support of sustainable outcomes. Formal instruments were suggested in the form of development management instruments with mandatory requirements,

including more stringent planning permit conditions, introducing an IWM overlay to Planning Schemes, design standards for green areas, and to prioritise sustainable outcomes in operations through more rigorous guidance strategies. Evidence audits by municipalities as an informal instrument is suggested to assist the knowledge transfer of what assets exist and what lessons can be learnt from their operation. Listing WSUD assets on property titles with instructions on their maintenance and function and prohibition of removal is suggested to protect WSUD's functionality and retention.

Social: To address the inadequate maintenance of WSUD assets on private land, informal tools of campaigns and education is suggested to raise awareness of WSUD's important function in removing pollutants from water bodies to make environmental impacts more relatable and understandable.

Table 5-4: Interview responses for practitioners' suggestions of planning initiatives to respond to barriers and drivers (continued overleaf).

Theme	Issue	Response	Planning Instrument Type	Implementation
Social				
(WR, 11 June, 2019)	Inadequate maintenance of WSUD assets on private land.	*Education* and awareness about the value of WSUD measures in reducing pollution loads in water bodies.	Informal: Public Relations (knowledge and promotion)	More government control over the construction and auditing of WSUD construction to ensure compliance and optimal design outcomes.
Economic				
(LG, 12 June, 2019)	Limited funding to realise integrated project outcomes.	Share *investment cost* among community investors.	Informal: Personal Relations (campaigns and partnerships)	Create a campaign funding scheme like a kick-starter platform to engage the community in partnering funds and ideas in the realisation of integrated projects with WSUD such as board walks and bike paths.
(PP, 14 June, 2019)	Large upfront investment cost.	Alternate arrangements and incentives for *investment costs*.	Informal: Incentive (financial)	Availability of payment plans, with no up-front costs and interest free periods.
Environment				
(PP, 14 June, 2019)	A lack of social value in stormwater quality.	Increase *environmental stewardship* and value of *ecosystem services*.	Informal: Personal Relations (education)	Quantify link between healthy water ways and the quality of the community's health and well-being which might also promote other co-funding arrangements.

Theme	Issue	Response	Planning Instrument Type	Implementation
Institutional				
(WR, 12 June, 2019)	Poor construction quality and maintenance of WSUD assets on private land.	*Leadership* and *responsibility* of construction and maintenance of WSUD measures.	Formal: Development management instruments (planning consent permits)	More government control over the construction and auditing of WSUD construction to ensure compliance and optimal design outcomes. And stringent monitoring of assets by developers
(WR, 12 June, 2019)	No knowledge of WSUD assets on private land.	*Knowledge transfer* about WSUD asset installations on private land for improved monitoring and evaluation of functioning WSUD assets.	Informal: Personal Relations (evidence audits)	Auditing and tracking audits through mapping or other register system.
(PP, 13 June, 2019)	Retention and function of WSUD assets on private land.	*Knowledge transfer* about WSUD assets.	Formal: Development management instruments (warranting of asset retention)	Property title indicates presence of WSUD assets with maintenance instruction and prohibition for removal.
(WR,12 June, 2019)	Limited integration of WSUD requirements.	*Policy integration* through the inclusion of an IWM overlay in the planning scheme.	Formal: Development management instruments (planning scheme overlay)	The overlay would consider how to minimise flooding, maximise quality and reuse and include requirements for different site conditions. As well as mapping of permeable surfaces, including privately owned open space areas.
(LG, 13 June, 2019)	A lack of mechanisms to trigger WSUD measures.	*Policy integration* of flooding management and mechanisms that trigger WSUD options and have mandatory requirements.	Formal: Development management instruments (planning consent permits)	Integration of policy to drive WSUD options to respond to flood management.
(PP, 14 June, 2019)	Disappearing green spaces in urban areas.	*Policy integration* to ensure that the design of urban places protects green spaces for WSUD measures.	Formal: Development management instruments	Protection of green landscaped areas through careful urban design of buildings to reduce their impermeable footprint.
(WR, 12 June, 2019)	Sustainable outcomes are often on a project basis.	*Leadership* and commitment to make sustainable outcomes a core part of business, so that a business case is not needed for each project to argue for WSUD.	Formal: Development plans (guiding strategies)	Strategies that prioritise sustainable outcomes in each project, so that WSUD is included across business operations.

5.3. Validating the Effectiveness of Planning Instruments and their Barriers and Drivers

To validate responses identified by the interviews, an online questionnaire was distributed to over 50 email addresses. The questionnaire had a response rate of 30 participants of which 26 participants completed the questionnaire fully. As findings are summarised in this section as a percentage, all responses have been included for analysis.

5.3.1. Respondent Profile

Respondents represented a diverse mix of practitioners and specialisations in WSUD across Greater Metropolitan Melbourne including 'private practice (i.e. consulting)' (43.3%), 'water utility employees' (26.7%), 'local government employees' (23.3%) and 'other' (6.7%). Those who identified as 'other' worked for 'government/ public service' and 'contractor to water utility and local government'.

- Respondents' experience with WSUD is multi-disciplinary, including expertise in:
- Strategy, urban/ water planning and development (15 respondents) with roles in project coordination, policymaking and review, government advisory and development assessment.
- Engineering (13 respondents) with specialisation in hydraulics, ecology, civil and often with a scientific application.
- Capacity building and education (1 respondent).

The next sub-sections present findings from the online questionnaire. Prevailing responses highlight consensus, and where two categories received the same score, both answers are listed.

5.3.2. Part A – Planning Instruments

The first part of the questionnaire qualifies practitioner's perception on how 'influential' they perceive local planning instruments for the construction of WSUD. This is measured on a five-point Likert Scale from 'direct influence' to 'no influence' with optional open comments for respondents to justify their answer choice and identify additional instruments to be included.

Formal Instruments - Local Mandates

Local mandates comprise Strategies (i.e. development plans) and Planning Schemes (i.e. development management instruments). Most respondents perceive that Local Mandates have influence in realising WSUD. Table 5.5 outlines findings of responses which are described below.

Strategies

Prevailing responses identify that *Water Plans* have the most influence in realising WSUD. *Greening of Public Spaces Plans* are considered 'moderate' to 'important' influence, *Greening of Private Spaces Plans* are considered 'weak' to 'moderate', and *Climate Adaptation Plans* are considered 'weak'. Open responses suggested that specific strategies for green infrastructure and waterway health should also be included in the questionnaire.

Strategic Council Plans are considered 'moderate' in their realisation of WSUD. An open response promotes their effectiveness because they set a business case and budget for WSUD projects, even though they are only reviewed every five years. An open response identifies that State Government initiatives have much more impact on strategic agendas as mandatory requirements, than champions at the local level. Responses recognise that Strategic Plans need to be part of the Planning Scheme to have impact.

Planning Schemes

Prevailing responses indicate that *Stormwater Management* prescriptive measures in Planning Schemes have a 'direct' influence in realising WSUD. Stormwater Management prescriptive measures are recognised by open responses as being important to achieve outcomes for WSUD in private development. Especially as Victorian Planning Provisions (VPPs) are mandatory requirements that must be implemented by municipalities. Sustainable Development prescriptive requirements were perceived as having 'important' to 'direct' influence, which could be attributed to their indirect address of WSUD.

Contract Agreements were also identified as having a 'direct' influence in realising WSUD, with a response promoting their role for securing the delivery of WSUD design in projects.

Municipal Strategic Statements are perceived as 'moderate' to 'important' in their influence,

Table 5-5: Summary of results for online questionnaire responses on formal planning instruments – Strategic Plans and Planning Schemes

Level of Influence	Strategic Plan	Planning Schemes
Direct	• Water Plans (37%)	• Stormwater Management (40.7%) • Contract Agreements (33.3%)
Important	• Greening of Public Spaces (33.3%)*	• Precinct Planning (44.4%) • Sustainable Development (25.9%)* • Municipal Strategic Statements (25.9%)*
Moderate	• Strategic Council Plans (33.3%)	• Sustainable Development (25.9%)* • Overlays (25.9%) • Municipal Strategic Statements (25.9%)*
Weak	• Greening of Private Space (33.3%)* • Climate Adaption (33.3%)	

*Answer has an equal rating across answer choices

promoted in open responses as they establish a framework for what development requirements can be included in a planning permit and are a guiding document that set the direction for Planning Schemes. However this framework still needs to be implemented.

Precinct Planning is perceived as 'important' in realising WSUD. An open response promotes spatial plans for their influential ability to nominate WSUD asset type and location. Overlays are also spatially relevant and are perceived as having an 'important' influence.

The *Local Planning Policy Framework* is identified as an additional instrument typology missing from the questionnaire and assists WSUD realisation by articulating what, how and where an assessing officer considers WSUD for a private development. However, responses recognise the limitation of local policies, as they are not mandatory State Government requirements.

Observations on Formal Instruments

Although respondents identify that strategies have value in establishing a framework and vision for the implementation of WSUD, they recognise that it is only the mandatory requirements within Planning Schemes that realise outcomes. Particularly State Government requirements in VPPs that need to be incorporated into local planning and are non-negotiable. That is, if there is only a vision and no 'stick' for implementation, there is no impact. The force needed behind mandatory requirements to realise WSUD reflects a development culture that does not prioritise best practice stormwater outcomes.

Strategies including Greening of Private Space and Climate Adaption are considered to have a 'weak' influence that may be related to these plans having an indirect link with stormwater management compared to Water Plans with a 'direct' influence and connection with stormwater.

For Planning Schemes, Stormwater Management prescriptive measures and Contract Agreements are considered as having 'direct influence', which reflects their specific inclusion of stormwater requirements, and creating an accountability for the delivery of requirements through legal agreement which was successfully used in the Inkerman Oasis development.

Precinct Planning was not identified as having a 'direct influence' which was an interesting result as it is widely used for urban renewal plans such as Fishermans Bend. However, as explained by responses, if plans are not mandatory, conceptual requirements could be negotiated and change the location of WSUD assets.

The results for formal instruments are not surprising as they validate interview responses about the importance of political leadership and commitment in planning decisions. Mandatory requirements therefore are indicated as being best enforced when they are a VPP and revealing a preference for more State Level control for WSUD requirements at a local government level.

Informal Instruments

Informal instruments comprise incentives (i.e. promotion of WSUD through financial benefits by local government) and public relations (i.e. initiatives that promote WSUD measures, but are not regulated, such as best practice guidelines). Responses across this instrument typology were less assertive and promotional of the instrument types. Table 5.6 outlines the findings of responses to informal instruments.

Incentives

Prevailing responses indicate that *Sponsors* are perceived to have the most influence in realising WSUD perceived as 'moderate' to 'important'. An open response draws on the experience of the Inkerman Oasis development as a demonstration project, where financial incentives were realised through leveraging the value of municipality land and raising profit from the sale of private housing. Another response affirms that sponsorship to deliver an initiative will increase the likelihood of realising WSUD.

Very few respondents expressed an opinion for *Exemptions* and *Bonuses*. Although, open responses promoted the positive contribution of exemptions in realising WSUD providing examples of municipality rebates and waiving planning permits for rainwater tanks. Open responses identified other incentive programs occurring worthy of investigation, including a project at Stringy Bark Creek, which offers incentives for local landowners to disconnect their stormwater from the local creek system. However, it is warned that managed delivery of incentives is important to recover their value, as if they are not properly connected to downpipes they will fail to operate in the long term. It is also cautioned that incentives can give a false message that WSUD is additional and not a necessary requirement.

Public Relations

Prevailing responses indicate that *Best Practice Guidelines* are perceived as having 'moderate' to 'direct' influence on realising WSUD. Open responses support their effectiveness when developers adopt them to improve the likelihood of a development approval, which can mainstream the approach in the development industry. However, if guidelines do not align to State Planning or have a lack of technical detail, they are redundant. Guidelines are criticised for communicating only elementary WSUD concepts for the broader community without sufficient technical detail for correct WSUD implementation.

Most respondents identify *Collaborative Research* and *Awareness* as having 'moderate' influence. Open responses recognise that the broader community has low literacy about the benefits of WSUD, arguing there is a great need for more education. Another response raises a concern about public perception of drought, water pricing and commitment to stormwater harvesting. They criticise that efforts to promote stormwater harvesting on a large scale by municipalities have lost momentum post the Millennium Drought. A lack of commitment to large-scale efforts, in favour of smaller, dispersed measures is cautioned for its short-sightedness in preparing for more dry conditions.

Table 5-6: Summary of results for online questionnaire responses on informal planning instruments- Incentives and Public Relations)

Level of Influence	Incentives	Public Relations
Direct		• Best Practice Guidelines (29.6%)*
Moderate	• Sponsors (37%)	• Collaborative Research (44.4%) • Awareness (40.7%) • Best Practice Guidelines (29.6%)*
No Opinion	• Bonuses (44.4%) • Exemptions (37%)	

*Answer has an equal rating across answer choices

Observations on Informal Instruments

Responses indicate that Incentives for WSUD are unknown to practitioners or there are few programs available, with a significant number of responses identifying 'No Opinion' and 'Moderate' on their influence. Despite the identification of incentive programs by open comment responses, these programs appear to represent exemplary examples or research cases, and not standard practice. The instrument mapping undertaken for Fishermans Bend supports this finding, where there were few local government incentives known by interview respondents or visible online though a desktop search of initiatives. This could reflect that either incentives are unavailable, or their availability is not transparent.

Practitioners had a better understanding of Public Relations related to promoted practitioner guides and research partnerships within the industry, through platforms such as the CRC for Water Sensitive Cities. In the instrument mapping for the Fishermans Bend project for example, there were a significant number of local government initiatives spanning guidelines to pilot projects and initiatives known by interview respondents and easily accessible online. However, practitioners criticise guidelines for their elementary language that does not target professionals who implement them. This reduces the opportunity to achieve Best Planning Practice (BPPs) because technical information is missing.

Guidelines although recognised for promoting awareness of WSUD, are also criticised for not aligning mandatory aims, targets and visions of the State Government. And that when there is a plethora of guidelines available without a mainstreamed approach, the transfer of knowledge to implement WSUD is incoherent to understand. This finding is echoed by the Victorian Stormwater Committee in their 2018 recommendations which promote more mandatory VPPs at the local government level (DELWP, 2018a). As municipalities have developed numerous and ad-hoc instruments, including best practice guidelines, which are inequitable and incoherent across so many development types and forms.

5.3.3. Part B – Additional Factors

The second part of the questionnaire had two objectives. First to quantify practitioners' perception of 'influence' of factors in the conceptual framework (see result summary in Table 5.7). Second, to identify which aspect practitioners consider the most influential barrier in realising WSUD, and which is the most influential driver. Findings are illustrated in Figure 5.1 and Figure 5.2 respectively. The findings identify that practitioners perceive the most influential driver as 'Environment', and the most significant barrier as 'institutional'. These findings, together with the interview responses and case studies are discussed in the next sub-section.

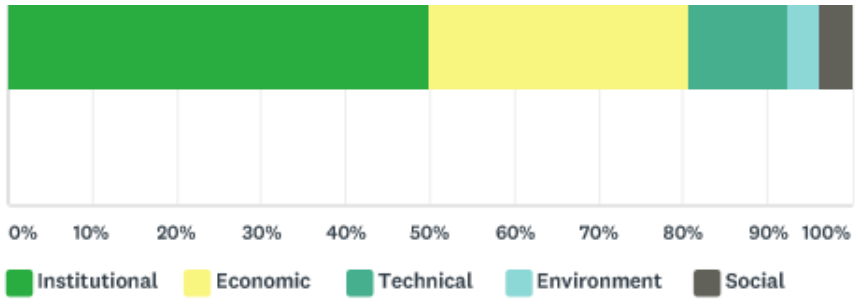

Figure 5.1: Summary of online questionnaire for the most significant barrier to realise WSUD outcomes.

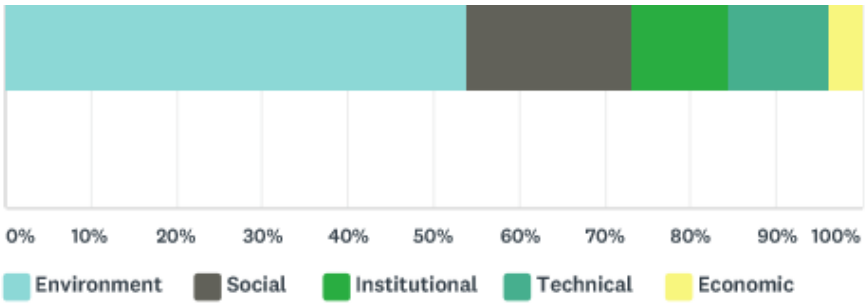

Figure 5.2: Summary of the most significant driver to realise WSUD outcomes.

Table 5-7: Summary of online questionnaire responses on additional factors.

	Factor Type				
Level of Influence	**Economic**	**Environmental**	**Institutional**	**Social**	**Technical**
Direct	• City Budget (54%) • Maintenance Cost (50%)	• Pollution (38.5%) • Environmental Protection (34.6%) • Climate Change (26.9%)	• Leadership (73%) • Commitment (57.7%) • Political will (top-down (53.8%) • Policy Integration (46.2%) • Responsibility (46.2%) • Expertise (42.3%)* • Workload (26.9%)*	• Ownership (53.9%) • Environmental Stewardship (46.2%)	
Important	• Investment Cost (50%) • Profit Margin Pressure (42.3%) • Market Swing (23.1%)*	• Multi-Benefits (61.5%)	• Knowledge Transfer (57.7%) • Priority (50%) • Collaboration (46.2%) • Expertise (42.3%)* • Workload (26.9%)* • Consultation (bottom-up) (57.7%) • Private Sector Influence (34.6%)	• Awareness (53.8%) • Acceptance (53.9%) • Adversity to Change (38.5%)	• Adaptability (65.4%) • Efficiency (57.7%) • Resilience (53.9%) • System Functionality (50%) • Vulnerability (38.5%) • Replication (34.6%)*
Moderate		• Ecosystem Services (40%) • Urban Cooling (38.5%) • Flood Risk (34.6%) • Urban Densification (30.7%) • Protected Landscape (30.7%)	• Silo Resourcing (47.3%) • Procedure Time (46.2%) • Procedure Legitimacy (42.3%) • Entrepreneurial (38.5%)		• Maturity (38.5%) • Replication (34.6%)*
Weak	• Insurance Cost (46.1%)				
No Opinion	• Market Swing (23.1%)*				

*Answer has an equal rating across answer choices

5.4. Discussion

The findings of barriers and drivers highlight the complexity of the governance landscape that influence the effectiveness ('influence') of local planning instruments in realising optimal WSUD outcomes, so that it is competitive with the centralised stormwater regime. Optimal functioning WSUD measures is critical. Otherwise initiatives can be redundant with no tangible improvement to stormwater management as demonstrated by the retrospective Inkerman Oasis project.

Fishermans Bend as a major urban renewal area which will develop over the next 30 years presents a significant opportunity to address persisting challenges, learning from past projects such as the Inkerman Oasis. So that the development's ambitious IWM system has the best possible support to not only achieve intended built outcomes but also that they operate as intended over the long term. As was shown in the case of Inkerman Oasis, even the most innovative systems can fail if planning does not account for checks and system maintenance. This section discusses findings of the interview responses, questionnaires and case studies with literature, to address implications for local planning instruments according the conceptual framework.

Economic

The economic aspect is considered as the second most influential barrier to realise WSUD which can be impacted by low financial resources in city budgets, spread too thin to maintain the functioning of assets. The rating of this aspect as an important barrier is consistent with other studies. Short-term thinking of financial investments in large projects can lose commitment when faced with financial hurdles, as experienced by the Fishermans Bend project, where the premature rezoning has increased land price which now challenges the business case to realise public realm WSUD.

Practitioners suggest incentive instruments could assist the financing of measures, such as using a community funding campaign to realise multi-benefit projects or through interest free loans (LG, 11 June, 2019; WR, 12 June, 2019). It is suggested for local government management of assets, internal management of budgets with asset maintenance planning would better align financial resources and responsibilities, which is crucial for the optimal functioning of measures (WR, 12 June, 2019). As shown in the example of the Inkerman Oasis project, without continued responsibility and maintenance planned from the outset, WSUD measures will become redundant. Other studies suggest that using evaluation criteria to communicate benefits could better promote private investment in measures (Qiao et al., 2018). Or informal networks to incentivise innovations with perceived risk (Kiparsky et al., 2016). It is agreed that these suggestions could positively influence the developer mindset in delivering BG Infrastructure, if incentives are made viable enough to compete with existing stormwater systems – and cause 'pressure' on the regime (de Haan & Rotmans, 2011). However, as illustrated by the instrument mapping there are few transparent, and or available incentives provided currently at the local government level. Incentives need to be further understood so that they can deliver quality outcomes, and not just be perceived as an 'add on' (PP, 13 June, 2019).

Environmental

This aspect was identified as the most important driver for realising WSUD. The importance of mitigating pollution and climate change in the study results highlights the value of public health and safety in stormwater management. An interesting observation is that multiple benefits are not as influential in the questionnaire, although were important drivers with interviewees. This may be attributed to multiple benefits being viewed as an exemplary outcome when they are achieved but do not represent the usual approach. Further, that management and response to flooding, may not always trigger WSUD for management, but a centralised and emergency response.

Responses identify a concern for the low community awareness of WSUD's environmental benefits, which can discourage developer investment, environmental stewardship of assets and compromise their design if they do not consider the environmental conditions of their location (Kuller et al., 2017). This is particularly critical as nature based systems are difficult to replicate with their dynamic dimensions (Alberti, 1999; Holling, 1978), and without consideration of place based conditions as was seen in a raingardens study (Browne et al., 2014), systems will fail. Therefore more awareness and education about ecosystems and conditions is needed.

Practitioners suggest that planning instrument guidelines should be better equipped with technical information improve WSUD, so that

they are better paired with place-based conditions to avoid 'copy and paste' replication failures (LG, 11 June, 2019). The poor pairing of capacity and operation of rainwater tanks in new developments in Fishermans Bend highlight how every situation is unique and needs a tailored approach. Current best practice guides on WSUD are criticised for their elementary language and for not aligning with State Government targets (WR, 12 June, 2019). This questions the purpose and intended audience of existing guidelines, if they are not usable in their requirements from a lack of detail or obligation to be followed.

Low awareness can also be addressed through marketing of synergistic benefits, especially urban cooling which is a significant topic for Australian cities (LG, 14 June, 2019). Low awareness and environmental stewardship reflects a larger society issue about the value and equity of natural resources. Particularly the protection of ecosystem functions. It suggests that to improve stormwater management there needs to be a much larger transition across society in paradigms about stormwater as a resource to more critically protect natural systems. Education can play an important role, but until a culture change emerges, it seems only mandated top-down actions will push for WSUD outcomes.

Institutional

Institutional aspects are perceived as the most significant barrier in the realisation of WSUD. Across interview and questionnaire responses, leadership, commitment and top-down political will are considered significant challenges which were related to flaws in WSUD design, maintenance and responsibility as was shown in the Inkerman Oasis project. The address of institutions and governance for better resilience in urban water governance is promoted as both a challenge and opportunity to progress sustainable development (Bulkeley, 2006; Koop & van Leeuwen, 2017). Based on the results for planning instruments, institutional challenges should be addressed using formal development management instruments that incorporate and enforce WSUD measures as a mainstream and integrated planning practice and development culture. As without enforcement of good WSUD practice there will be no impact, and with reliance on incentives, WSUD measures can be perceived as an addition, not a standard. This addresses the knowledge gap about the effectiveness of planning instruments, highlighting the mandatory requirements are the most effective. Practitioners recommended many policy reform ideas to address institutional barriers, such as mainstreaming IWM by introducing an overlay to Planning Schemes, design standards for green areas, and to prioritise sustainable outcomes in operations through more rigorous guidance strategies. Evidence audits by municipalities as an informal instrument is suggested to assist the knowledge transfer of what assets exist and what lessons can be learnt from their operation. Listing WSUD assets on property titles with instructions on their maintenance and function and prohibition of removal is suggested to protect WSUD's functionality and retention. Other studies recognise that knowledge transfer is an important driver between institutions and sharing of resources, as well as innovations in collaboration (Qiao et al., 2018). Increasing the significance of WSUD in local planning will also require changes to staff resourcing and training. This questions whether amongst other priorities, local planning is equipped to undertake new responsibilities, or whether water retailers or Integrated Water Management Forums should assist.

Social

This aspect was identified as second most influential barrier to realise WSUD, sharing similar responses with the environmental aspect. Practitioners recognise that low community awareness of WSUD benefits is a challenge for widespread acceptance of the approach. This has implications not only in commitment to and knowledge on how to manage assets, but resistance in realising WSUD, and commitment in the design phase to achieve best practice design that will function in the long term. Practitioners suggest that informal instruments of education to raise public awareness of environmental benefits could assist, such as information about how stormwater quality and WSUD measures influence health and well-being (PP, 14 June, 2019).

However, as raised by other responses, despite knowledge on the benefits of WSUD, realising measures can be resisted because they cost time and money. To address this, planning instruments could more transparently communicate benefits of WSUD. For example, by using a framework that transparently makes data available and uses specific, measurable, achievable, relevant and time bound targets for WSUD assets (Koop & van Leeuwen, 2017). Even though a formal approach would create more impact, it is also important to consider

principles of good water governance (UNDP Water Governance Facility, n.d.), which includes equal rights and opportunities in decision-making processes, so that community interests are also represented in WSUD mandates.

Technical

Across interview and questionnaire responses, technical aspects were identified as 'moderate' to 'weak' in realising WSUD. Interview responses identified system functionality and replication as a barrier in the implementation of WSUD. However, the explanation behind these aspects has a notable overlap with institutional factors in terms of design guidance and process, rather than an absence of technology. This finding highlights the importance of Best Planning Practices (BPPs) (i.e. planning for location) and Best Management Practices (BMPs) (i.e. design for function) to optimise the functionality of WSUD measures (Kuller et al., 2017). As mentioned with the Environment aspect, improvement of BMPs and BPPs can be improved through more technical information in guidelines to transfer knowledge about how to couple measures to protect important ecological processes. Findings for technical aspects in literature related to other issues. Specifically, issues with adaptability of systems in a highly urbanised area with fragmented open space (Schuch et al., 2017)and reliability with concerns for low system performance (Dhakal & Chevalier, 2017). These issues may have also been relevant, however were not addressed by respondents in this study.

5.5. Research Questions

This thesis posed two research questions to address the research problem about a lack of understanding on how local planning instruments can leverage the wider adoption of BG Infrastructure. The research questions are outlined and addressed below.

***Research Question No.1*: How influential are local planning instruments in the delivery of BG Infrastructure?**

Hypothesis No. 1: Local planning instruments are influential in the delivery of BG Infrastructure as they form part of development approval processes. However, the level of influence is related to how directly the instrument addresses BG Infrastructure and its inclusion of detailed guidance.

Local planning instruments comprise formal and informal instruments. The study findings indicate that for the Melbourne study case, the most influential local planning instruments are those that formally mandate BG Infrastructure and are tied to State Government requirements such as Victorian Planning Provisions within local Planning Schemes. Formal planning instruments that have the most 'direct influence' are Stormwater Management prescriptive measures and Contract Agreements within Planning Schemes as they also mandate requirements. Mandates are identified as necessary as they commit to outcomes, rather than leaving outcomes open for planning assessment discretion and negotiation. Formal planning instrument Strategies are considered important in setting an overarching vision, however if there is no way to implement and enforce the visions, no tangible result will be realised.

Informal planning instruments are not very influential in Melbourne. Practitioners identify a lack of knowledge on financial incentives, and instrument mapping indicates a lack of transparency and, or existence of incentives. Public Relations as informal instruments are well known and recognised amongst practitioners for increasing awareness of WSUD in the planning industry through their advocacy, collaboration and education role. However, their influence in realising optimal outcomes for WSUD is limited. This limitation arises from a lack of technical guidance particularly critical for ecosystem services coupling to achieve optimal outcomes for place-based site conditions. Further the large number of guidelines adds to complexity and confusion if plans do align with State Government requirements.

The hypothesis to this research question is correct that local planning instruments are influential in realising BG Infrastructure in Melbourne, however this is not only related to the direct inclusion of BG Infrastructure and detailed guidance, although important. Critically 'influence' is most related to mandates and enforcing the realisation of measures. However, physical realisation of measures does not guarantee optimum functioning of WSUD assets, which is addressed in the answer to the second research question.

***Research Question No. 2:* How can local planning instruments be strengthened to address perceived barriers, and drive the implementation of BG Infrastructure?**

Hypothesis No.2: Local planning instruments can address influential factors that form part of the governance landscape, to support the transition of BG Infrastructure from a niche to regime stormwater management approach.

Through the investigation of barriers and drivers using a conceptual framework of factors, this thesis identifies that influential factors that form part of the governance landscape could be addressed by local planning instruments – which supports the hypothesis to this research question. As highlighted by the discussion in this chapter, barriers and drivers present many implications for local planning instruments. The most important barrier and driver are the Institutional and environmental aspects, respectively.

Institutions were identified as the most significant barrier in realising BG Infrastructure in the Melbourne study case. They present a lack of priority for realising WSUD outcomes, commitment to BG Infrastructure outcomes, performance monitoring and maintenance, lack of responsibilities planned for the correct building of assets, as well as inconsistency between policy instruments. These issues question whether local government is best placed to drive the implementation of BG Infrastructure, or whether regional level planning, aligned with water catchments needs, is more effective to overcome these challenges by driving BG Infrastructure in a more strategic and authoritarian way. The newly established Integrated Water Management Forums provide an opportunity to review the role of local planning instruments in addressing BG Infrastructure and provide a new platform for collaborative governance at regional and local level.

The environmental aspect was identified as the most significant driver in realising BG Infrastructure. This result recognises that public awareness and knowledge about BG Infrastructure benefits is limited outside of the planning industry. Also limited, is knowledge about the coupling of ecosystem services and the importance of locating BG Infrastructure in a place where it will optimally function. WSUD guidelines are criticised for a lack of technical detail. However, to capture the complexity of ecosystem design, technical detail needs to be place-based, to successfully consider unique site conditions. Education about this issue through informal planning instruments can play an important role. Practitioners suggest that marketing multi-benefits of BG Infrastructure is a practical way to engage interest, by relating measures to the topics of urban cooling and heat which is a relatable experience for the Melbourne community. Therefore to drive BG Infrastructure from a niche to a regime stormwater approach it is important to address community awareness of its benefits but also to improve institutional processes in local planning.

5.6. Chapter Summary

This chapter presented results from the interviews, questionnaire responses and case studies to identify the influence of local planning instruments in realising WSUD. These findings indicate that institutional and environmental aspects are the most influential on BG Infrastructure in local planning. Local planning instruments that mandate outcomes and are tied to State Government requirements are important to make impact, as the results show that without enforcement or mandatory obligation outcomes will not be realised.

As discussed in this chapter, these findings have important implications and leave open questions for local planning instruments. Specifically, how can local planning respond to the most significant barrier of institutional factors? Is local government the appropriate governance level to manage WSUD effectively? And how can environmental factors be leveraged to drive WSUD realisation more effectively? Chapter 6 presents conclusions and proposes policy recommendations, with final remarks on study limitations and opportunity for further research.

6. Conclusions and Recommendations

Reasons for the slow adoption of BG Infrastructure are highlighted in this study's findings which have important implications for local planning instruments in how they can more effectively drive optimal uptake of measures. This chapter concludes the study highlighting key findings and proposing policy recommendations. Specifically, on how to address the most significant barrier of institutions, and how to promote environment as a driver to more effectively realise Best Planning Practice outcomes. Limitations of the study are outlined and opportunities for further research are suggested.

6.1. Study Conclusions

This study investigated the influence of local planning instruments to realise BG Infrastructure appreciating that local planning is well placed to address stormwater management in the design of urban environments. Investigating two case study projects in Melbourne, Australia, illustrated that although there has been a growth in science, technology and policies for Water Sensitive Urban Design (WSUD), persisting barriers remain in WSUD planning.

Notable findings across the Melbourne study are:

- Even though practitioners recognise the value of WSUD, the measures are often compromised from flaws in **institutional** processes and arrangements that impact optimal design outcomes and long-term maintenance of systems, perceived as the most significant barrier.
- **Environmental** benefits of WSUD are not well known amongst the broader community. Although this presents a challenge in the implementation of WSUD, practitioners identify that better awareness of environmental benefits is a key driver in realising improved outcomes.
- **Formal instruments** that are mandatory requirements, specifically those tied to State Government policy, have the most impact in realising optimal WSUD outcomes. As without force, practitioners recognise that WSUD will not be prioritised in the design outcome. Further, there needs to be better integration of instruments to unlock and simplify the delivery of multiple benefits of WSUD. Realising multiple benefits of WSUD will not only deliver improve environmental outcomes but will also make the approach more attractive and promotable to the community.
- Even though **informal instruments** are available, their influence in realising WSUD outcomes is questionable. Practitioners identify a lack of knowledge on available incentives, and an over-supply of best practice guides, which are critiqued to be incoherent (i.e. not aligning with State Government requirements) or not providing adequate detail to achieve successful design and implementation of measures.
- Since the development of the Inkerman Oasis development, there is more industry recognition and political support for WSUD implementation, however there is a persisting problem of unclear instrument guidance and responsibilities of asset performance over the long term. These issues impact the functionality of WSUD which can all together make measures redundant. This is an issue faced by the Fishermans Bend urban renewal project, which if not addressed will impact this important part of the city's expansion to the vulnerability of flooding in the future.

The findings therefore highlight, that even though Melbourne is identified as performing well towards the Water Sensitive City (WSC) goal, the city's efforts still have significant challenges to address. Policy change may assist in leapfrogging (Binz et a., 2012) ahead, should urban planning for BG Infrastructure be prioritised. The next sub-section suggests some recommendations to policy that promote the WSC agenda in the Melbourne context.

6.2. Recommendations

Recommendations seek to leverage the positive direction of three recent initiatives in green space and water management in Greater Metropolitan Melbourne which were addressed in chapter 4. The first, is the establishment of Integrated Water Management (IWM) Forums, which provide a timely discussion on the multi-level governance structure of stormwater management. Recommendations are suggested in this section as to what functions these Forums could have, shared or separate from local government planning. It is suggested that level is required.

The second, is the recent vegetation mapping initiative which can support the coupling of WSUD measures with vegetation types for improved place-based outcomes and support of ecosystem services. Thirdly, the review of *Urban Stormwater Best Practice Environmental Management Guidelines 1999 (BPEM)*. The Guideline at the time of its implementation set an important precedent and understanding of WSUD across the Victorian planning industry. The review and update of the Guideline provides an opportunity to address some persisting barriers that influence local planning

instruments to champion and advance BG Infrastructure project, more authority above local government

This study recognises that different local planning instruments are available to manage stormwater in the urban environment, and can guide, suggest and enforce the implementation of BG Infrastructure. However, as results identify, the level of influence that local planning instruments have in realising an optimal outcome is often compromised due to undercurrent institutional flaws. Further, developer resistance to integrate WSUD outcomes in their development is related to a low community awareness of WSUD's environmental benefits. Table 6.1 outlines a selection of issues identified in the study's findings related to institutional (grey) and environment (green) with suggested recommendations.

Table 6-1: Proposed recommendations to issues.

	Issue	Recommendation
● ●	Limited institutional accountability of whether WSUD assets have been (a)realised on private land and (b) where they are located.	Local governments to require assets on private land to be recorded on land property titles with maintenance instructions. The location of assets are mapped and communicated to IWM Forums. IWM Forums to have a statutory authority role with a specialist team check the correct implementation, maintenance and functioning of assets on an annual basis.
● ●	WSUD guidelines and strategies at a local planning level are inconsistent, lack technical detail about ecosystem services, and do often do not align with State Planning.	IWM Forums to develop new catchment WSUD guidelines to supersede existing inconsistent guidelines. New guidelines to provide detailed guidance on local ecosystem services and technical design requirements for optimal functioning. Guidelines could be supported with mapping on ground cover permeability, land slope, ground water table levels, vegetation types, water bodies and existing centralised infrastructure. The mapping approach is based on the Hanseatic City of Hamburg's Geoportal (https://geoportal-hamburg.de) which provides public access to detailed environmental mapping to inform development proposals.
●	Local government leadership, testing and championing WSUD outcomes, often falls behind other priorities in planning, or is avoided because of perceived risk	Local planning instruments to mandate surface permeability in on private new developments and integration of WSUD measures. Permeability could be calculated as a percentage of the site area.
●	Low public awareness of WSUD environmental benefits.	Wider marketing of urban cooling and forestation together with WSUD, more transparent financial incentives to encourage private developers to adopt WSUD, and improved integration between green space planning and WSUD outcomes.

6.3. Limitations of Study

This study encountered several limitations related to definitions and methodology. Definition limitations relate to the differences between WSUD and IWM. Some scholars identify that WSUD now more broadly refers to IWM which is a whole of urban water cycle approach (Fletcher et al., 2015). However, as this study focuses on stormwater management, it blurs the definition of terms. For this reason, it was difficult to separate descriptions of stormwater management from IWM practices in case studies and interviewee responses and so water aspects in addition to stormwater were also addressed. Another definition limitation is the difference between BG Infrastructure undertaken by developers on public land, and projects undertaken on private land. It is recognised that these two project types have significant differences including funding and governing arrangements. These differences could have been more clearly defined with respondents to distinguish between them.

Four main limitations were identified for the study's methodology. The first relates to spatial scale, involving the investigation of two local government areas in Melbourne. The investigation of this governance landscape was intended; however it limits the transferability of findings to other city contexts in Australia and other countries.

The second relates to participant involvement in the study which was dependent on gate keeper contacts and good will. There were noticeably fewer interview respondents with knowledge on the Inkerman Oasis, which is reflected in the study results with information lacking on planning instruments for the project. The representativeness of data from questionnaire responses is also worth noting, with a response rate of 30 practitioners across the Greater Metropolitan Melbourne area. Ideally a larger number of respondents would have participated from only inner-city municipalities, however it was necessary to make distribution less restrictive to increase response numbers.

Thirdly, the online questionnaire over simplified instrument and factor descriptions. A few respondents indicated that they did not understand all categories referenced, which could also be related to their experience. However the intent of simplifying the questionnaire, was to provide a generalised list of instruments which could apply to the two case study projects. Comment space was provided to identify missing instruments, however as the questionnaire was not replicated, there was no possibility to include additional identified instruments.

Lastly, due to time and study scope, the instrument mapping did not include a detailed review of instrument objectives and controls. Instead the mapping was guided by interviewee responses and a review of online documents to briefly understand the key intent of each instrument type to create categories that could be used in the questionnaire. A more detailed review of instruments would have allowed for more detailed analysis in the results of this study.

6.4. Opportunities for Further Research

This thesis contributes to a growing body of research investigating how BG Infrastructure can progress towards a WSC as a niche technology to a regime stormwater management approach. This research was undertaken with support of the Urban Water Management research division of the Swiss Federal Institute of Aquatic Science and Technology (Eawag, ETH University Zürich). Eawag's strategic research program WINGS investigates innovative alternatives to centralised water management encompassing structural solutions as well as governance aspects.

This thesis identifies that although local planning instruments play an important role in shaping built environment outcomes to manage stormwater, their investigation in scholarly research has been limited. This study in its attempt to better understand the influence of local planning instruments contributes to this scholarly work and identifies opportunities for further research listed below.

- Replication of this study in another city setting to build a comparison base between instruments and barriers and drivers to realise BG Infrastructure;
- A detailed investigation of Fishermans Bend and its planning instruments as an innovative IWM precinct faced with significant flooding challenges, and how planning instruments can be optimised to deliver multi benefits, optimal design of assets, maintenance and monitoring to

enable their functionality over the longer term;

- Study of regional governance models that could be adopted or used to inform a designated authority to authorise the design, location and monitoring of BG Infrastructure at a catchment scale, in coordination with local governments;
- How local planning instruments can facilitate Best Planning Practice in the location of assets to protect ecosystem services;
- How the benefits of BG Infrastructure can be most effectively communicated to the public to raise awareness of their importance and promote a development culture that values the assets.

6.5. Final Remarks

The niche approach of BG Infrastructure provides a promising solution for cities to address impacts from a changing climate and increasing stormwater runoff from growing impervious surfaces. The role of local planning instruments has a great potential to shape built form outcomes to support stormwater management practices, however as the study findings highlight for the Melbourne context, reform is needed to address persisting barriers. The investigation of two case study projects reveal how challenges for realising BG Infrastructure continue despite advances in science, technology and policy frameworks. The results of this study indicate that more efforts need to address institutional and environmental aspects that influence the governance framework of local planning instruments. This is to ensure that BG Infrastructure is not only physically realised, but also designed optimally, so that ecosystems are protected and measures function over the long term.

This thesis identifies the opportunity for reform to occur with the establishment of the IWM Forums' whole of catchment planning to take a larger share of local planning responsibilities to facilitate strong leadership and coherence. Further the review of BPEM and the release of detailed vegetation mapping provide an opportunity to increase public awareness about BG Infrastructure multi-benefits, and significantly in the Melbourne context – urban cooling. The Water Sensitive City is an ambitious but necessary goal. Cities will need to continue their adaptation efforts as they grow and face climate pressures. Reflecting on past lessons of BG Infrastructure is an important next step to improve its practice.

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Appendix

APPENDIX A – Interview Protocol, Consent Form and Supporting Material

INTERVIEW PROTOCOL

Resource Efficiency in Architecture and Planning (REAP) Master Thesis
Summer Semester 2019

Title: 'The potential of local planning instruments to unlock blue-green solutions for decentralised stormwater management'

Student: Emily Salvisberg
HCU Supervisors: Prof. Dr Ing.Wolfgang Dickhaut and Prof. Dr. Martin Wickel

QUESTIONS

A – Knowledge and experience with decentralised stormwater management (5 mins)

- What is your experience, role and knowledge of Water Sensitive Urban Design (WSUD)?
- Were you involved in the case study project xx? If yes – what was your involvement?

B – Identification of relevant planning instruments and stakeholders (15 mins)

- I have mapped local planning instruments for Council xx, relevant to WSUD for medium to high density residential apartment buildings. I categorised the instruments as mandates (formal), incentives (informal) and public relations (informal). **Refer Table 1.**
    - Which instruments are missing?
    - Which are specific to dense residential developments?
    - Are there any other or new instruments currently being discussed, trialled or formalised that you are aware of?
    - From the instruments listed, which is the most influential in realising WSUD for dense residential developments**?**
      For each instrument, which stakeholders are important to engage? **Refer Table 2**

C – Barriers and drivers for project implementation (15 mins)

- From literature, I have identified additional factors that are barriers and, or drivers for WSUD implementation. **Refer Table 3**. What other factors can you think of?
    - How do you perceive the role of WSUD pilot projects?
    - How is asset maintenance planned for in the design stage?
- What changes would you recommend to strengthen the influence of local planning instruments to realise WSUD measures? (e.g. incentives, synergies/ multi-benefits, quantifiable mandates)

D – Further participant involvement (5 mins)

- Do you have any other comments?
- To quantify opinions on influential instruments and factors for WSUD, I will distribute an online questionnaire.
- Are you happy to participate?
- Can you forward the questionnaire to other colleagues also working with WSUD?

EXPLANATORY STATEMENT

Resource Efficiency in Architecture and Planning (REAP) Master Thesis
Summer Semester 2019

HafenCity University Hamburg (HCU) in partnership with the Swiss Federal Institute of Aquatic Science and Technology (Eawag).

Title: 'The potential of local planning instruments to unlock blue-green solutions for decentralised stormwater management'

Student: Emily Salvisberg
HCU Supervisors: Prof. Dr Ing.Wolfgang Dickhaut and Prof. Dr. Martin Wickel

You are invited to take part in my master thesis project. Please read this Explanatory Statement for an understanding of my research before deciding whether or not to participate. If you have any questions or would like further information, please contact me at: emily.salvisberg@hcu-hamburg.de

What does the research involve?
The aim of my study is to explore how local planning instruments can realise the physical implementation of blue-green solutions for stormwater infrastructure, specifically for medium to high density residential developments.

You are invited to participate in a semi-structured interview. The interview will last for about 45 minutes. Questions will be based upon the following topics:
A - Interviewee knowledge and experience with blue-green solutions
B - Identification of relevant planning instruments and stakeholders
C - Barriers and drivers for project implementation
D - Further participant involvement

Why were you chosen for this research?
You are a practitioner and/ or have experience on projects relating to decentralised stormwater infrastructure. You would have been contacted directly by myself or through your colleague, who would have recommended you to be part of this project.

Consenting to participate in the project and withdrawing from the research
Before the commencement of the interview or questionnaire, you will be asked to sign a consent form. You have the right to withdraw from further participation at any stage. It will not be possible to withdraw the answers given after the interview.

Possible benefits and risks to participants
The findings of this research will help identify how decentralised stormwater projects can be realised in dense residential areas. The data captured will support Eawag's ongoing development of UrbanBEATS, a GIS-based planning-support model. This research does not put you at any personal risk and will only require some of your time.

Confidentiality and storage of data
Any data collected during this research will be treated confidentially. Upon completion of this research, de-identified raw data will be stored securely on Eawag and HafenCity University servers for the required amount of years before it is then destroyed. Interviews will be recorded and transcribed, and direct quotes will only be used with consent of participants. No personal details will be shared with any third party at any time.

CONSENT FORM

Resource Efficiency in Architecture and Planning (REAP) Master Thesis
Summer Semester 2019

HafenCity University Hamburg (HCU) in partnership with the Swiss Federal Institute of Aquatic Science and Technology (Eawag).

Title: 'The potential of local planning instruments to unlock blue-green solutions for decentralised stormwater management'

Student: Emily Salvisberg
HCU Supervisors: Prof. Dr Ing.Wolfgang Dickhaut and Prof. Dr. Martin Wickel

You are invited to participate in the master thesis as stated above. Please read the Explanatory Statement and indicate your consent for the following:

	Y	N
Taking part in a semi-structured interview	□	□
Audio recording during a semi-structured interview	□	□
Any follow-up conversations by telephone/ or email for clarification of answers in the interview	□	□
Data provided during this research will be used for this project. Any direct quotations will be consented to over email.	□	□
Future research will build upon the data provided to this project.	□	□
Contact details for further involvement in this project	□	□

Preferred Contact Details

Name:

Email address:

Phone:

Participant Signature:

Date:

Accompanying Interview Material

Table 1- Planning Instruments Mapping

	Relevant Stormwater Instruments			
Instrument Type	**National**	**State**	**Regional**	**Local**
FORMAL				
Mandates (i.e. regulatory requirements)				
INFORMAL				
Incentives (e.g. financial)				
Public Relations (e.g. guidelines, demonstration projects, ecological labels, media and awareness)				

Table 2– Stakeholder Mapping

Local Planning Instruments			**Relevant Stakeholders**	**Other**
Formal	**Mandates** (i.e. regulatory requirements	Local Environmental Plan	State Government, Local Government and regulatory authorities, citizens	
Informal	**Incentives** (e.g. financial)	Development Contributions Plans	Local Government, banks, investors, developers	
	Public Relations (e.g. guidelines, demonstration projects, ecological labels, media and awareness)	Water Sensitive Urban Design Guidelines	Local Government, citizens, environmental groups	

Accompanying Interview Material (Continued)

Table 3 – Additional Factor Mapping

Additional Factors	Type	Description	Other
Economic	City Government's Budget	Allocated resourcing list by the local government.	
	Investment Cost	Costs associated with technology investment and construction including land value, materials and labour.	
	Insurance Costs	Costs associated with flooding or stormwater damage.	
Environmental	Flood Risk	Likelihood of a flood occurrence.	
	Environmental Protection	Protection of natural environmental quality of an area.	
	Pollution	Disturbance or improvement to the quality of water.	
	Urban Cooling	Reduction of hard surfaces heat retention in urbanised areas.	
	Protected Landscape	Limitations and restrictions to the development of land, such as heritage conservation.	
	Ecosystem Services	Promoting the benefits of biodiversity, infiltration and recreation of areas.	
	Climate Change	Promotion of adaptation and mitigation measures to reduce climate disturbances.	
	Urban Densification	A lack of available space for decentralised technologies.	
Institutional	Political will	Support or no support for prioritisation of decentralised technologies.	
	Procedure	Lengthy or efficient administrative processes to approve development.	
	Expertise	Knowledge of technology and its implementation requirements.	
	Workload	Capacity of administrative staff to support decentralised technology.	
	Knowledge Transfer	Knowledge sharing between professionals to support technology adoption.	
	Silo Resourcing	Isolated organisational and resource flows.	
	Priorities	Hierarchy of performance goals and deliverables.	
Social	Adversity to Change	Uncertainty about new technology transferability.	
	Awareness	Knowledge of technology and its implementation benefits.	
	Acceptance	Knowledge and agreement of technology and its implementation benefits.	
	Ownership	Support, advocacy and responsibility for technology implementation.	
Technical	System State and Capacity	Ability of system to maintain a well performing functionality.	
	Vulnerability	Robustness of the system performance.	
	Adaptability	Flexibility of the system to change to new requirements.	
	Resilience	Flexibility of system to withstand external pressure.	

APPENDIX B – Online Questionnaire and Results

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Driving (Blue-Green) Water Sensitive Urban Design Approaches

Resource Efficiency in Architecture and Planning (REAP) Master Thesis

HafenCity University Hamburg in collaboration with the Swiss Federal Institute of Aquatic Science and Technology (Eawag, ETH Zürich)

Dear participant,

Thank you for your interest in my master thesis study, on how local planning can realise Water Sensitive Urban Design (WSUD), in dense urban areas.

Green-blue infrastructure seeks to capture the synergistic benefits of urban greening and water management. In my research I focus on WSUD for stormwater management, and WSUD measures are defined to include: raingardens, constructed wetlands, evaporation basins, green roofs, green walls, infiltration systems, pervious pavements, stormwater tanks, retarding basins, sand/ gravel filter systems, sediment ponds and swales.

Please set aside 10 minutes to complete this questionnaire. By participating, it is assumed that you give your consent for the results to be used in my study. All answers will be kept anonymous.

Questionnaire Overview:

Part A – asks your opinion as a rating, on the influence of local planning instruments to realise WSUD measures.

Part B – asks your opinion as a rating, on the influence of additional factors that are barriers and, or drivers for WSUD measures.

Ready to begin?

* 1. **INTRODUCTION**
To start, please identify the area that you (primarily) work in:

- ○ Private Practice (i.e. consultant)
- ○ Local Government Employee
- ○ Water Utility Employee
- ○ Other (please specify)

* 2. Please state in general terms, your involvement with WSUD. For example, a hydrology engineer, planning assessment officer, infrastructure coordinator, strategic advisor etc.

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Driving (Blue-Green) Water Sensitive Urban Design Approaches

Part A - Planning Instruments

In this questionnaire, local planning instruments to inform the design and physical implementation of WSUD in the context of Melbourne, have been identified by interviews with local WSUD practitioners. Examples are provided from the City of Port Phillip and the City of Melbourne.

Instruments are categorised in the questionnaire as formal (i.e. mandates) and informal measures (i.e. incentives and public relations).

For each category of instrument, you are asked to rate from your knowledge and, or experience, its influence to achieve the physical realisation of WSUD measures (i.e. WSUD measures are built). The scale of influence uses a 5-point Likert Scale, where:

1 = No influence (i.e. WSUD is not realised)
2 = Weak influence (i.e. WSUD is rarely realised)
3 = Moderate influence (i.e. WSUD is realised sometimes)
4 = Important influence (i.e. WSUD is realised most of the time)

5 = Direct influence (i.e. WSUD is realised)

Where you have no knowledge of the instrument type, there is a 'no opinion' option.

* 3. **LOCAL MANDATES - Strategies**
Regulatory requirements set by local strategies (i.e. frameworks and actions) that are used in local government assessment processes. Using the Likert Scale, please rate how influential you perceive each of them to be, in realising WSUD measures.

	NA - No opinion	1 - None	2 - Weak	3 - Moderate	4 - Important	5 - Direct
Strategic Council Plans i.e Whole of Municipal priorities and actions Example. *Future Melbourne 2016 - 2026*	○	○	○	○	○	○
Greening of Public Spaces i.e. Design and management of public open spaces Example. *Greening Port Phillip – an Urban Forest Approach 2010*	○	○	○	○	○	○
Greening of Private Spaces i.e. Design of private open spaces. Example. *Green our City Strategic Action Plan – Vertical and Rooftop Greening in Melbourne 2017-2021*	○	○	○	○	○	○

	NA - No opinion	1 - None	2 - Weak	3 - Moderate	4 - Important	5 - Direct
Water i.e. Actions and targets to manage water resources. Example. *City of Port Phillip Water Plan 2010*	○	○	○	○	○	○
Climate Adaptation i.e. Actions to address impacts. Example. *City of Melbourne Climate Change Adaptation Strategy Refresh (2017)*	○	○	○	○	○	○

Are any important instruments missing? Do you have any further comments?

* 4. **LOCAL MANDATES - Planning Schemes**

Regulatory requirements set by local planning schemes (i.e. prescriptive measures) that are used by local government to determine development approval. Using the Likert Scale, please rate how influential you perceive each of them to be, in realising WSUD measures.

	NA - No opinion	1 - None	2 - Weak	3 - Moderate	4 - Important	5 - Direct
Municipal Strategic Statement i.e. Key framework for land use and development, including zoning and priority actions. Example. *City of Melbourne Municipal Strategic Statement (2010)*	○	○	○	○	○	○
Contract Agreements i.e. Municipal requirements over a precinct, to be fulfilled by land developers. Example. *Section 173 Agreement (Planning and Environment Act 1987)*	○	○	○	○	○	○

	NA - No opinion	1 - None	2 - Weak	3 - Moderate	4 - Important	5 - Direct
Overlays i.e. Mapping of special features such as flooding, which is controlled by planning conditions and permits. Example. Special Building Overlays (SBO) Set appropriate conditions and floor levels to address flood risk.	○	○	○	○	○	○
Precinct Planning i.e. Development standards for designated precincts. Example. *City of Melbourne's Clause 22.27 Fishermans Bend Urban Renewal Area Policy (2018)*	○	○	○	○	○	○
Sustainable Development i.e. Development standards for design outcomes. Example. City of Port Phillip's *Clause 22.13 Environmentally Sustainable Development (2015)*	○	○	○	○	○	○

	NA - No opinion	1 - None	2 - Weak	3 - Moderate	4 - Important	5 - Direct
Stormwater Management i.e. Development standards for design outcomes. Example. City of Melbourne's *Clause 22 Stormwater Management (Water Sensitive Urban Design) (2015)*	○	○	○	○	○	○

Are any important instruments missing? Do you have any further comments?

* 5. **INCENTIVES**

Incentives promote WSUD measures but are not regulated, for example, financial benefits provided by local government to developers. Using the Likert Scale, please rate how influential you perceive each of the incentives to be, in realising WSUD measures.

	N/A - No opinion	1 - None	2 - Weak	3 - Moderate	4 - Important	5 - Direct
Bonuses i.e. An additional allowance when WSUD measures are delivered. Example. City of Melbourne's *Design and Development Overlay 10:* Allows floor area uplift in exchange for provision of public benefit including publicly accessible open space.	○	○	○	○	○	○
Exemptions i.e. Removal of requirements when WSUD measures are delivered. Example. City of Port Phillip's *Sustainable Design Strategy 2011: waives planning permit fees for rainwater tanks and grey water systems.*	○	○	○	○	○	○

	N/A - No opinion	1 - None	2 - Weak	3 - Moderate	4 - Important	5 - Direct
Sponsors i.e. Financial partners to deliver WSUD measures. Example. Council funding contributions to cooperative research and local pilot projects	○	○	○	○	○	○

Are any important instruments missing? Do you have any further comments?

* 6. **PUBLIC RELATIONS**

Public relations includes initiatives that promote WSUD measures, but are not regulated, such as best practice guidelines. Using the Likert Scale, please rate how influential you perceive each of the incentives to be, in realising WSUD measures.

	N/A - No Opinion	1 - None	2 - Weak	3 - Moderate	4 - Important	5 - Direct
Awareness i.e. Raise the profile of WSUD measures amongst citizens and professionals. Example. Council Alliance for a Sustainable Built Environment (CASBE): A collection of Victorian municipal governments working towards sustainable built environments.	○	○	○	○	○	○

	N/A - No Opinion	1 - None	2 - Weak	3 - Moderate	4 - Important	5 - Direct
Collaborative Research i.e. Cooperate in opportunities to drive WSUD measures. Example. City of Melbourne's research demonstration green infrastructure projects including Green Your Laneway and Green Our Rooftop.	○	○	○	○	○	○
Best Practice Guidelines i.e. Guide citizens and the development community in WSUD practices. Example. City of Port Phillip's *WSUD Guidelines Applying the Model WSUD Guidelines* (an initiative of the Inner Melbourne Action Plan)	○	○	○	○	○	○

Are any important instruments missing? Do you have any further comments?

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PART B - Additional Factors

Other influencing factors (e.g. economic and institutional) play a role in driving or

creating barriers for WSUD measures to be physically realised (i.e. built).

For each factor listed, please rate from your knowledge and, or experience, its influence using the same 5-point Likert Scale, where 1 = no influence and 5 = direct influence.

* 7. ECONOMIC (i.e. availability of funding)

Using the Likert Scale, please rate how influential you perceive the following factors to be, in realising WSUD measures.

	1 - None	2 - Weak	3 - Moderate	4 - Important	5 - Direct
City Government's Budget	○	○	○	○	○
Investment Cost	○	○	○	○	○
Insurance Cost	○	○	○	○	○
Market Swing	○	○	○	○	○
Maintenance Cost	○	○	○	○	○
Profit Margin Pressure	○	○	○	○	○

* 8. **ENVIRONMENT (i.e. impacts on the natural environment)**

Using the Likert Scale, please rate how influential you perceive the following factors to be, in realising WSUD measures.

	1 - None	2 - Weak	3 - Moderate	4 - Important	5 - Direct
Climate Change	○	○	○	○	○
Ecosystem Services	○	○	○	○	○
Environmental Protection	○	○	○	○	○
Flood Risk	○	○	○	○	○
Multi- Benefits	○	○	○	○	○
Pollution	○	○	○	○	○
Protected Landscape	○	○	○	○	○
Urban Cooling	○	○	○	○	○
Urban Densification	○	○	○	○	○

* 9. **INSTITUTIONAL (i.e. governance organisation)**

Using the Likert Scale, please rate how influential you perceive the following factors to be, in realising WSUD measures.

	1 - None	2 - Weak	3 - Moderate	4 - Important	5 - Direct
Collaboration	○	○	○	○	○
Commitment	○	○	○	○	○
Consultation (bottom-up)	○	○	○	○	○
Entrepreneurial	○	○	○	○	○
Expertise	○	○	○	○	○
Leadership	○	○	○	○	○
Knowledge Transfer	○	○	○	○	○
Procedure Time	○	○	○	○	○
Procedure Legitimacy	○	○	○	○	○
Policy Integration	○	○	○	○	○
Political Will (top-down)	○	○	○	○	○
Priority	○	○	○	○	○
Private Sector Influence	○	○	○	○	○
Responsibility	○	○	○	○	○
Silo Resourcing	○	○	○	○	○
Workload	○	○	○	○	○

* 10. **SOCIAL (i.e. perception of WSUD)**

Using the Likert Scale, please rate how influential you perceive the following factors to be, in realising WSUD measures.

	1 - None	2 - Weak	3 - Moderate	4 - Important	5 - Direct
Adversity to change	○	○	○	○	○
Awareness	○	○	○	○	○
Acceptance	○	○	○	○	○
Environmental Stewardship	○	○	○	○	○
Ownership	○	○	○	○	○

* 11. **TECHNICAL (i.e performance of WSUD)**

Using the Likert Scale, please rate how influential you perceive the following factors to be, in realising WSUD measures.

	1 - None	2 - Weak	3 - Moderate	4 - Important	5 - Direct
Adaptability	○	○	○	○	○
Efficiency	○	○	○	○	○
Maturity	○	○	○	○	○
Replication	○	○	○	○	○
Resilience	○	○	○	○	○
System Functionality	○	○	○	○	○
Vulnerability	○	○	○	○	○

* 12. From the categories of additional factors explored, which do you perceive to be the most influential **barrier** for WSUD?

- ○ Economic
- ○ Social
- ○ Environment
- ○ Technical
- ○ Institutional

* 13. From the categories of additional factors explored, which do you perceive to be the most influential **driver** of WSUD?

- ○ Economic
- ○ Social
- ○ Environment
- ○ Technical
- ○ Institutional

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Questionnaire End

Thank you for participating!

I welcome any feedback or questions you have about my thesis project.

APPENDIX C – Inkerman Oasis Stakeholder and Planning Instrument Map

Inkermann Oasis, St Kilda (City of Port Phillip) – Stakeholder and Planning Instrument Map

Key: Desktop Research (prior interviews) | Interviewee Input | Post Interview Research

Table 1 - Planning Instrument Mapping (1994 - 2003)

	Instrument Hierarchy			
Instrument Type	**National**	**State**	**Regional** (i.e. more than 2 council areas)	**Local (CoPP)**
FORMAL				
Mandates (i.e. regulatory requirements)		**General – Urban Planning** • ***Planning and Environment Act 1987:*** Governs planning for the state. (DELWP, 2019a; WR pers comms. 12 June, 2019) • ***Local Government Act 1989:*** Sets out local Government responsibilities under delegation of the state. Section 173 Agreement of this Act provides a contract between the Council and a Landowner for requirements on land. (VicWater, n.d; Rose Lawyers 2016; PP pers comms. 14 June, 2019) • ***Building Act 1993:*** Governs building activity for the State. (DELWP, 2019a; WR pers comms. 12 June, 2019) • ***Melbourne 2002 – 2030:*** the Victorian Government's long-term plan for managing Melbourne's growth and development. (Port Phillip City Council, 2010) **Specific – Water Planning** • ***Health Act 1958:*** assists in protecting public health in Victoria in partnership with the community. (VicWater, n.d) • ***Environment Protection Act 1970:*** Requirements for protection of ecosystems and water quality controls. (VicWater, n.d) • ***Water Act 1989:*** The primary piece of water legislation in Victoria. It provides the legal framework for water management and use across Victoria, including the issuing and allocation of water entitlements and the provision of water services by state-owned water corporations and catchment management authorities. (VicWater, n.d) • ***Catchment and Land Protection Act 1994 (the CaLP Act):*** establishes a Catchment Management Authority (CMA) for each region. (VicWater, n.d) • ***State Environment Protection Policy (Groundwater of Victoria) 1996.*** (Environment Protection Authority Victoria, n.d.) • ***Urban Stormwater – Best Practice Environmental Management Guidelines (BPEMG) 1999:*** Set out best practice guidance and objectives for urban stormwater management. (Victorian Stormwater Committee, 1999; LG pers comms, 13 June, 2019) • **Environment Protection Authority *Use of Reclaimed Water Guidelines 2003.*** (Environment Protection Authority Victoria, 2003)		**Strategies** • ***City of Port Phillip Housing Strategy 1997:*** Under the community housing section, strategy 6.3.10 seeks for the inclusion of sustainable design principles in Council's community housing program. In particular, it seeks to incorporate sustainable design, including water recycling, in housing projects where possible by building on the experience of the first project to incorporate this, the 100 Argyle Street, St.Kilda Project. (PP pers comms, 14 June, 2019) **Contract** • ***Section 173 Agreement (Planning and Environment Act 1987):*** The master plan for the site was as an agreement and locked in by way of an encumbrance on the title. (Aspin, 2007) • **South East Water Environmental Improvement Plan.** Contracted to address the guidelines from the Environment Protection Authority *Use of Reclaimed Water Guidelines 2003.* (Farrelly & Davis, 2009) **City of Port Phillip Planning Scheme** • ***Clause 14.02-3S Water conservation*** • ***Clause 19.03-3S Water supply, sewerage and drainage*** • ***Clause 19.03-4S Stormwater*** • ***Clause 55.03-4 Permeability*** • ***Clause 56.07 Integrated water management*** • **Overlays for flooding** (DELWP, 2019b)

Abbreviations: City of Port Phillip (CoPP) |Department of Environment, Land, Water and Planning (DELWP) | Local Government (LG) | Private Practice (PP) | Water Retailer (WR) |

Inkermann Oasis, St Kilda (City of Port Phillip) – Stakeholder and Planning Instrument Map

Key: Desktop Research (prior interviews) | Interviewee Input | Post Interview Research

Table 2– Key Stakeholder Mapping

Planning Instruments		Relevant Actors and Stakeholders	Representation	Role
Formal	**Mandates**	Victorian Department of Infrastructure	Victorian State Government	Processed the rezoning of the site from Public Purposed – Local Government to Mixed Use. (Farrelly & Davis, 2009)
		Environment Protection Authority (EPA)	Victorian State Government	Operates under the *Environment Protection Act 1970* to prevent pollution and protect the environment to the levels required by State environment protection policies. This includes approvals and licences, research development and demonstration approvals, emergency approvals, notices and enforcement.(Environment Protection Authority Victoria, 2019)
		Melbourne Water Corporation (MW)	Victorian State Government	State-owned metropolitan bulk water and sewerage company that are the flood plain managers of western Port Phillip Bay, including polluted water treatment and drinking water with responsibility for metropolitan scale infrastructure that is greater than 60ha in area. (LG pers comms, 11 June, 2019)
		South East Water Pty Ltd. (SEW)	Water Authority	Water retailer, providing drinking water, sewerage, trade waste and recycled water services to customers, and approval for connections to water network. (South East Water, 2019)
		Urban Land Corporation (ULC)	Victorian State Government	It is the Victorian Government's property development agency delivering urban renewal, established in 1997 and now referred to as Places Victoria. (Aspin, 2007)
		City of Port Phillip (CoPP)	Local Government	Local authority and landowners of the site. Council supported the City of St Kilda Housing Strategy, acting as a direct provider of social housing as Port Phillip Housing. The Council was the lead developer and subcontracted the work through a Section 173 Agreement under the *Environment and Planning Act 1987* with Ecumenical Housing Inc (EHI). The Council had a strong agenda for the implementation of Environmentally Sustainable Development Principles. Council established a steering committee for the project comprising consultants: • Urban Land Corporation: Engaged to assist in the preparation of a masterplan and tender preparations for the site. After the remediation of the site, the ULC had completed their contractual involvement with the CoPP. • Ecumenical Housing Inc (EHI): Initially engaged as consultants that prepared an options paper about possible ownership models, financial feasibility study, legal and management structures when the site was first investigated. The Council adopted a trust agreement in land ownership transferral. Inkerman Developments Pty Ltd was the chosen developer and a Public-Private Partnership was established. Key consultants engaged to support the site's Master Plan included: • Architects William & Boag: Engaged in preliminary discussions as an advisor to Council for the site's future and developed the approved masterplan. • McGauran Soon Architects: Secondary advisors to Council, after Architects William & Boag. • Integrated Eco Villages: Nominated consultant to supply, install and operate the on-site grey water management system. They also negotiated the regulatory approvals as at the time there were no clear regulatory approval processes to support the system. Confusion of the system meant that construction had started before conversations with regulatory authorities. (Aspin, 2007; Farrelly & Davis, 2009; PP pers comms. 14 June, 2019)
Informal	**Financial Incentives**	The Ecumenical Housing Trust	Private Trust	The Ecumenical Housing Trust was used by the CoPP as a vehicle to hold ownership of the site in order to get best value from a range of taxes and duties. This was based on sale of some social units to the Office of Housing and cross subsidisation from the sale of private units. (Aspin, 2007)
		Living Cities, Urban Stormwater Initiative Program (2000/2001)	Commonwealth Government	The scheme awarded funds to the initiative of a combined greywater and stormwater recycling process to be delivered on site. The combined wastewaters were to be used for toilet flushing and landscape irrigation; a first of its kind in Victoria. The grant enabled the provision also of water balancing flow control device in the plumbing system throughout the project to maintain consistent pressure. (Farrelly & Davis, 2009)
		South East Water Pty Ltd (SEW)	Water Authority	Provided financial support for the innovative system including 6 months free operation monitoring and maintenance of the plant (Aspin, 2007) and an innovation grant to help the operation of the recycling system which required a chlorine dosing step to meet regulatory authority requirements. (Farrelly & Davis, 2009)
	Public Relations	Standards Australia	Industry Bodies	WaterMark certification system of technologies used (Farrelly & Davis, 2009)
		South East Water Pty Ltd	Water Authority	The Authority had an interest in the water treatment and re-use system as an opportunity for research and development of decentralised water management, and perceived their involvement as actively influencing policy makers to develop regulatory guidelines for the use of recycled water. The Authority agreed under contract with the Body Corporate of the development to maintain and operate on-the onsite water system and monitor for a period of 6 years. They set a precondition to have support from the Department of Human Services and the Environmental Planning Authority to assist with implementation, along with additional requirements including: a community education plan, a plumber awareness plan and a verification plan. (Farrelly & Davis, 2009)

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Abbreviations: City of Port Phillip (CoPP) |Department of Environment, Land, Water and Planning (DELWP) | Local Government (LG) | Private Practice (PP) | Water Retailer (WR) |

		• ***Constitution (Water Authorities) Act 2003:*** keeps the responsibility for ensuring the delivery of water services in public hands. (VicWater, n.d) • ***Safe Drinking Water Act 2003:*** Protects and improves the quality of drinking water supplies in Victoria. (VicWater, n.d) • ***Water Legislation (Essential Services Commission and Other Amendments) Act 2003:*** Establishes the Essential Services Commission (ESC) as the economic regulator of the water industry. (VicWater, n.d) • ***State Environment Protection Policy (Waters of Victoria) 2003.*** (Environment Protection Authority Victoria, n.d.)		
Instrument Type	**National**	**State**	**Regional** (i.e. more than 2 council areas)	**Local (City of Port Phillip)**
INFORMAL				
Incentives (eg. financial)	• Commonwealth Grant Funding: Living Cities, Urban Stormwater Initiative Program (2000/2001) (Farrelly & Davis, 2009)			South East Water • Provided financial support for the innovative system including 6 months free operation monitoring and maintenance of the plant (Aspin, 2007) and an innovation grant to help the operation of the recycling system which required a chlorine dosing step to meet regulatory authority requirements. (Farrelly & Davis, 2009)
Public Relations (eg. guidelines, demonstration projects, ecological labels, media and awareness)	**Awards** • Commendation Award – National Built Environment Exemplar 2004 – Sustainable Communities Category. (Farrelly & Davis, 2007) • National Royal Australian Institute of Architects Special Jury Award 2005 – Business Sustainability. (Farrelly & Davis, 2007) • Howard Desbrowe-Annear Award 2005 – Victoria Residential Architect (Farrelly & Davis, 2007)			South East Water • Opportunity for research and development of a decentralised water management system. (Farrelly & Davis, 2009) • Contract agreement with the development's Body Corporate to maintain and operate on-the onsite water system and monitor for a period of 6 years. (Farrelly & Davis, 2009) • Contract agreement for assistance from Department of Human Services and the Environmental Planning Authority to assist with a community education plan, a plumber awareness plan and a verification plan. (Farrelly & Davis, 2009)

APPENDIX D –Fishermans Bend Stakeholder and Planning Instrument Map

Fishermans Bend, St Kilda (CoM and City of Port Phillip) – Stakeholder and Planning Instrument Map

Key: Desktop Research (prior interviews) | Interviewee Input | Post Interview Research

Table 1 - Planning Instrument Mapping (2019 current and ongoing)

	Instrument Hierarchy			
Instrument Type	**National**	**State**	**Regional** (i.e. more than 2 council areas)	**Local**
FORMAL				
Mandates (i.e. regulatory requirements)	• ***Water Efficiency Labelling and Standards Act 2005:*** Provides information reducing water consumption for purchasers of water-use and water-saving products; and to promote the adoption of efficient and effective water-use and water-saving technologies. (Australian Government, 2019a) • ***The Water Act 2007:*** Management framework for Australia's largest water resource—the Murray-Darling Basin. (Australian Government, 2019a) • ***National Water Initiative 2007:*** commits states and territories to innovation and capacity-building to create Water Sensitive Australian Cities (Clause 92). This agreement called for Australia to develop national guidelines for evaluating options for water-sensitive urban development and urged a review of the institutional models for achieving integrated urban water-cycle planning and management. Under the NWI, governments commit to: prepare comprehensive water plans; achieve sustainable water use in over-allocated or stressed water systems; introduce registers of water rights and standards for water accounting; expand trade in water rights; improve pricing for water storage and delivery; and better manage urban water demands. (Australian Government, 2019b) • ***Urban National Construction Code (Building Code of Australia) 2015:*** Provides technical provisions for the design and construction of buildings and other structures throughout Australia. The Victorian variation requires Class 1 homes to have a rainwater tank that is plummed into for	**General – Urban Planning** • ***Planning and Environment Act 1987:*** Governs planning for the state. (DELWP, 2019; WR, pers comm. 12 June, 2019) • ***Local Government Act 1989:*** Sets out local Government responsibilities under delegation of the state. (DELWP, 2019a; WR, pers comm. 12 June, 2019) • ***Building Act 1993:*** Governs building activity for the State. (DELWP, 2019a; WR, pers comm. 12 June, 2019) • ***Plan Melbourne 2017-2050:*** Metropolitan Strategy planning for sustainable growth to deliver more sustainable built environments. (DELWP, 2019b) • ***Apartment Design Standards Victoria 2017:*** Standards apply to buildings above 5 storeys and address ESD and green roofs and vertical greening, waste and water and open space. The standards are complemented by new design guidelines for apartment buildings. An apartment buyers and renters guide is planned along with a training program for planning and building design practitioners. (DELWP, n.d.; PP, pers comm. 14 June, 2019) **Specific – Water Planning** • ***Health Act 1958:*** assists in protecting public health in Victoria in partnership with the community. (VicWater, n.d) • ***Environment Protection Act 1970:*** Requirements for protection of ecosystems and water quality controls. (VicWater, n.d) • ***Water Act 1989:*** The primary piece of water legislation in Victoria. It provides the legal framework for water management and use across Victoria, including the issuing and allocation of water entitlements and the provision of water services by state-owned water corporations and catchment management authorities. (VicWater, n.d; WR, pers comms. 12 June, 2019) • ***Catchment and Land Protection Act 1994 (the CaLP Act):*** establishes a Catchment Management Authority (CMA) for each region. (VicWater, n.d) • ***Urban Stormwater – Best Practice Environmental Management Guidelines (BPEM) 1999:*** Set out best practice guidance and objectives for urban stormwater management. The Environment Protection Authority (EPA) is reviewing and is likely to recommend an expanded range of stormwater management standards to reflect changes in stormwater	**General – Regional** • ***Melbourne Water Flood Management Strategy – Port Phillip and Westernport 2015.*** (Melbourne Water, 2015; WR, pers comms. 12 June, 2019) • ***Central Region Sustainable Water Strategy 2015 – 2055:*** a series of actions and augmentations to meet the region's water needs. (Department of Land, Environment, Water and Planning, 2019c) • ***Resilient Melbourne 2016:*** Part of the 100 Resilient Cities by the Rockefeller Foundation (100RC), which helps cities around the world prepare to meet the physical, social and economic challenges that are a growing part of the 21st century. The CoM leads the initiative and works in collaboration with Greater Melbourne councils. An action includes supporting integrated water management frameworks. (Resilient Melbourne, n.d.; WR, pers comms. 12 June, 2019 2019) • ***Yarra River Action Plan 2017:*** details 30 actions to ensure the long-term protection of the Yarra River and its parklands. (Melbourne Water, 2019; WR, pers comms. 12 June, 2019 2019) • ***Melbourne Water, Healthy Waterways Strategy 2018 -2028:*** Shared strategy across Melbourne Water, state and local government, water corporations and the community. It provides strategic direction towards a regional vision for the health of rivers, estuaries and wetlands in the Port Phillip and Western port region. (Melbourne Water, 2019; WR, pers comms. 12 June, 2019 2019) **Specific – Fishermans Bend Renewal** • ***A Community Infrastructure Strategy 2017:*** The Fishermans Bend Taskforce is identifying the future community facilities and services for residents and workers that will be required as the Fishermans Bend population grows. (Department of Jobs, Precincts and Regions, 2019) • ***Fishermans Bend Framework 2018 to 2050*****:** long-term strategic plan, accompanied by planning controls for	**City of Melbourne - Strategies** • ***Municipal Strategic Statement 2010:*** Key strategic planning, land use and development objectives for a municipality and includes strategies and actions. It provides the strategic basis for the application of local policies as well as zones and overlays. The CoM's Municipal Strategic Statement includes reference to vegetated rooftops as a method for increasing biodiversity in cities. The Municipal Strategic Statement is due to be updated this year. (CoM, 2010) • ***Open Space Strategy 2012:*** Addresses management of open space as well as adaptation to climate change challenges after a decade of drought and water restrictions. (CoM, 2012a; LG, pers comm. 11 June, 2019) • ***Urban Forest Strategy: Making a great city greener 2012 – 2032:*** Strategy aims to adapt to climate change, mitigate the heat island effect and become a water sensitive city. (CoM, 2012b; LG, pers comm. 11 June, 2019) • ***Total Water Mark – City as a Catchment 2014 – 2018:*** Overall plan for integrated water cycle management and provides broad direction and focus, including high-level targets. (CoM, 2018; LG, pers comm. 11 June, 2019) • ***Future Melbourne 2016 - 2026:*** Council strategic plan, with priority 14 to Capture and reuse stormwater. Specifically, that Melbourne will conserve water and improve the health of its waterways by capturing stormwater. (CoM, 2016) • ***Climate Change Adaptation Strategy Refresh 2017:*** Five goals to deliver, partner and advocate for climate change adaptation. Goals include for example: enhancing the natural environment and green spaces, to shape the built form and urban renewal areas to withstand future climate change impacts and to build adaptation capabilities and expertise. (CoM, 2017a; LG, pers comm. 14 June, 2019) • **Green our City Strategic Action Plan – Vertical and Rooftop Greening in Melbourne 2017-2021:** A focus on facilitating green infrastructure in the private realm. (CoM, 2017b; LG, pers comm. 14 June, 2019) • ***Municipal Integrated Water Management Plan 2017 – 2021:*** Sets the strategic direction on water management across the municipality, using a place-based and catchment approach. Based on *the Total Water Mark Strategy 2014*. (CoM, 2017c; LG, pers comm. 11 June, 2019) • ***Nature in the City – Thriving Biodiversity and Healthy Ecosystems 2017:*** Main goals are to create diverse, connected, and resilient natural environment, to connect people to nature and demonstrate leadership in urban ecology and conservation of biodiversity. (CoM, 2017d; LG, pers comm. 14 June, 2019) • ***Stormwater Drainage Design Guidelines 2019:*** Provides precinct specific requirements and aligns with Fishermans Bend Strategic Framework Plan. For new developments with an increase in floor area in excess of 50 m2 it requires the incorporation of Integrated Water Cycle Management principles into stormwater drainage design. This approach can serve the dual purpose of providing temporary

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		groundwaters across the State. (Environment Protection Authority, n.d.) • ***Melbourne Metropolitan Sewer Strategy 2018***: Addresses the sewerage system's role in a water sensitive city and in Melbourne's waste management. Outlines where policy and regulation can meet strategic aims. (Melbourne Water, n.d.) • ***Clause 19.03-3S Victoria Planning Provisions 2018:*** introduced a new integrated water management policy to embed objectives and strategies in urban land-use planning. This requires adoption of an integrated approach to the planning, design and assessment of new developments which brings all the elements of the water cycle together, including sewage management, water supply, stormwater management and water treatment, to maximise community and environmental benefits. (DELWP, 2019d; LG, pers comms. 13 June, 2019) • ***Amended Clause 53.18 - Victorian Planning Provisions 2018:*** Stormwater management in urban development, have been introduced to extend the existing stormwater management requirements for residential subdivision and apartment developments to all commercial and industrial subdivisions and developments, all public use developments and all residential multi-dwelling developments. (DELWP, 2019d; PP, pers comms. 13 June, 2019) • ***Clause 55.07-5 – Victorian Planning Provisions 2018:*** Integrated water and stormwater management objectives for apartment buildings developments of four storeys or less (excluding a basement). With requirements including: buildings should be designed to collect rainwater for non-drinking purposes such as flushing toilets, laundry appliances and garden use; and buildings should be connected to a non-potable dual pipe reticulated water supply where available from the water authority. (DELWP, 2019d; PP, pers comms. 13 June, 2019) • ***Clause 58.03-18 – Victorian Planning Provisions 2018:*** Integrated water management requirements for apartment developments of five or more storeys (excluding a basement) in a residential zone. With requirements including: collect rainwater for non-drinking purposes such as flushing toilets, laundry appliances and garden use; and buildings should be connected to a non-potable dual pipe reticulated water supply where available from the water authority. (DELWP, 2019d; PP, pers comms. 13 June, 2019)	An overarching public space strategy will provide an indicative plan for public space to cater for a range of community experiences. It will also identify funding models for public space and investigate potential opportunities for delivering additional open space in Fishermans Bend. (Department of Jobs, Precincts and Regions, 2019) • ***Draft: Smart City and Integrated Infrastructure Strategies:*** An integrated infrastructure plan is being developed that will look at opportunities to embed smart city thinking into the design and operation of infrastructure to manage utilities and resources more efficiently and support increased resilience. (Department of Jobs, Precincts and Regions, 2019)	• ***Sustainable City Action Plan 2017 – 2020:*** Outlines the Actions that Council will take to support the community to reduce their greenhouse gas emissions, water use and waste. (CoPP, 2017) • ***Act and Adapt: Sustainable Environment Strategy 2018-2028:*** Sets out the Council's commitment to environmental sustainability within the organisations towards a greener, cooler more liveable City, reducing impacts on the environment and are more resilient to the impacts of climate change. In support of this Strategy, the Council is developing internal organisation plans. (CoPP, 2018) • ***Council Plan 2019 – 2027:*** *Strategic Plan with a goal to be a water sensitive city seeking to reduce potable water consumption by encouraging more efficient water use and establishing alternative water sources. Also to Improve the quality of water entering Port Phillip Bay and increasing ground permeability.* (CoPP, 2019) **<u>CoPP Planning Scheme</u>** • ***LPP Clause 21.03 Ecologically Sustainable Development (2018)*** • ***LPP Clause 22.2 Stormwater Management (Water Sensitive Urban Design) (2014)*** • ***LPP Clause 22.13 Environmentally Sustainable Development (2015)*** • ***LPP Clause 22.15 Fishermans Bend Urban Renewal Policy (2018)*** • ***VPP Clause 44.05 Special Building Overlay (SBO 2)*** • ***VPP Clause 53.18 Stormwater Management in Urban Development*** • ***VPP Clause 56.07 Integrated Water Management*** (DELWP, 2019a) • **Sustainable Design Assessment in the Planning Process (SDAP):** The framework applies to residential and non-residential development for new buildings or extensions to existing buildings which are greater than or equal to 50 square meters. The SDAPP stormwater management objective is commensurate with Clause 22.12 and aims to reduce the impact of stormwater run-off by encouraging the incorporation of water sensitive urban design into urban development design. It requests a Sustainable Design Assessment (SDA) or a Sustainable Management Plan (SMP) depending on the size of the development, that outlines any proposed sustainable design initiatives that will improve the overall performance of the development. (CoPP, n.d.a; LG, pers comms. 13 June, 2019)
Instrument Type	**National**	**State**	**Regional** (i.e. more than 2 council areas)	**Local**
INFORMAL				
Incentives (eg. financial)	• Unknown	• Commissioning the preparation of blue- green Guidelines which will be available through Melbourne Water, so all councils can use and	• ***Melbourne Water, Living Rivers Funding:*** Offers councils funding, expertise and guidance to build their	**<u>City of Melbourne</u>** • Partnering with Resilient Melbourne as part of the 100 Resilient Cities Program, to deliver the Resilient Melbourne Strategy action to support

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	toilet flushing. A review to be released in 2022, with Victorian Government considering options for rainwater management for brownfield and one to one replacement houses. (PP, pers comms. 13 June, 2019 2019) •	science and technology advances over time and associated impacts. (Victorian Stormwater Committee, 1999; LG, pers comms. 13 June, 2019) • ***Constitution (Water Authorities) Act 2003:*** keeps the responsibility for ensuring the delivery of water services in public hands. (VicWater, n.d) • ***Safe Drinking Water Act 2003:*** Protects and improves the quality of drinking water supplies in Victoria. (VicWater, n.d) • ***Water Legislation (Essential Services Commission and Other Amendments) Act 2003:*** Establishes the Essential Services Commission (ESC) as the economic regulator of the water industry. (VicWater, n.d) • **Clause 56 Victorian Planning Provisions 2006:** implement the neighbourhood principles set out in Melbourne 2030. Its objectives support integrated water management and subdivision construction site management. It promotes a more sustainable basis for managing water in residential subdivisions by conserving potable (drinking) water, providing opportunities for reusing and recycling water for non-drinking purposes and managing the quality as well as quantity of urban run-off objectives set out in State Environment Protection Policy (Waters of Victoria). The standards to be met include performance objectives set out in the BPEMG, which can be met by incorporating water sensitive urban design. (Environment Protection Authority Victoria, 2014; PP, pers comms. 13 June, 2019) • ***Water Amendment (Governance and Other Reforms) Act 2012 (Governance Act):*** The Governance Act establishes a more uniform and improved governance and operational framework for all state-owned water businesses in Victoria. (VicWater, n.d) • ***Victorian Waterway Management Strategy 2013:*** Health of river systems. (VicWater, n.d) • ***Victorian Floodplain Management Strategy 2016:*** The floodplain management strategy is designed to ensure appropriate response and action is taken in the event of a flood. (DELWP, 2019e) • ***Water for Victoria 2016:*** A strategic plan for a future with less water as Victoria responds to the impact of climate change and a growing population. (DELWP, 2019f) • ***Integrated Water Management (IWM) Framework for Victoria 2017****:* Outlines the Victorian Government's approach and has established 15 forums across Victoria (five in metropolitan Melbourne) to undertake collaborative planning. (DELWP, 2019g) • ***State Environment Protection Policy (Waters):*** provides a framework for the protection and management of water quality in Victoria, covering surface waters, estuarine and marine waters and	the development of Fishermans Bend to guide investment and development by the Victorian Government, local governments and the private sector. Sustainability Goal 5 is for a water sensitive community with the objectives to design the urban form to accommodate sea-level rise and storm events and establish an integrated water system across Fishermans Bend to provide access to high quality potable and recycled water. A catalyst project, a recycled water plant is planned to provide water through third pipe to buildings. (WR, pers comms. 12 June, 2019; Department of Jobs, Precincts and Regions, 2019) • ***South East Water's Conditions of Connection 2019:*** Requirement for new developments in Fishermans Bend to supply: easy to access individual tenancy water meters installed on both the drinking water and Class A recycled water supply services; and a temporary third pipe interconnection at the inlet valve of the recycled water main water meter to charge the recycled water internal plumbing system with drinking water until such time that a recycled water reticulated supply is available. (WR, pers comms. 12 June, 2019; South East Water, 2019) • ***South East Water Technical Sewer and Water Standards:*** information and requirements on the design, construction and product selection for all water and sewer infrastructure in its licensed area. (WR, pers comms. 12 June, 2019) • ***Melbourne Corporation's Draft Fishermans Bend Water Sensitive Drainage & Flood Management Strategy2019:*** Collaboratively developed with Fishermans Bend Taskforce Drainage Working Group to explore the potential to use distributed flood storages in streetscapes and open spaces as an alternative to the 'baseline' drainage infrastructure (i.e. pipelines and pump stations) including rigorous assessment of options. (WR, pers comms. 12 June, 2019) • ***Draft Fishermans Bend Funding and Finance Strategy:*** Details on how community facilities and services will be funded and delivered. (Department of Jobs, Precincts and Regions, 2019) • ***Draft: A Public Space Strategy:***	flood storage on a lot scale, while also reducing the demand for potable water supply. (CoM, 2019; LG, pers comm. 11 June, 2019) ***Draft Strategy with Green Factor:*** Requires a portion of the site to have green space, which is decided through using an online calculator, with the aim to help with urban cooling. (LG, pers comm. 14 June, 2019) **City of Melbourne Planning Scheme** • ***LPP Clause 22 Stormwater Management (Water Sensitive Urban Design) (2015)*** • ***LPP Clause 22.27 Fishermans Bend Urban Renewal Area Policy (2018)*** • ***LPP Clause 22.19 Energy, Water and Waste Efficiency (2013)*** • ***VPP Clause 44.05 Special Building Overlay (SBO 2)*** • ***VPP Clause 53.18 Stormwater Management in Urban Development*** • ***VPP Clause 56.07 Integrated Water Management*** (DELWP, 2019a) **City of Port Phillip - Strategies** • ***Open Space and Water Management Plan – Towards a Water Sensitive City 2010****:* Objectives are to maintain and improve the health of trees; maintain and improve the health and liveability of parks and open spaces, now and into the future; find and use alternative water sources, and increase water efficiency; and use innovative water sensitive urban design and other adaptation measures to adapt to a drier and hotter climate. (CoPP, 2010a) • ***CoPP Water Plan 2010:*** with objectives to clarify current and future water management challenges and issues of relevance to council; outline a vision and principles for sustainable water management, including potable water, stormwater, wastewater and groundwater; set targets for integrated water management across all water sources; outline a sustainable water management program of council and community actions, incorporating regional and local partnerships; outline elements of program support including water project accounting, program monitoring and communications planning. (CoPP, 2010b) • ***Climate Adaptation Plan – Climate Adept City (2010):*** *Objectives and actions to create a climate resilient city with better responses to flooding and heat. (WR, pers comm. 12 June, 2019)* • ***Greening Port Phillip – an Urban Forest Approach 2010:*** Provides the strategic framework and policy context for the development and management of trees, recognising trees cannot be managed in isolation from other elements of the urban environment. (CoPP, 2010c; LG, pers comms. 13 June, 2019) • ***Sustainable Design Strategy 2011:*** The Strategy introduces Sustainable Design with a vision for the municipality and outlines other relevant Council policy. It defines how Council intends to influence development to achieve more sustainable outcomes by defining eligible development and how sustainable design criteria can be satisfied through the planning process. Finally, it outlines how Council will advocate for a more sustainable approach by engaging with the development community and industry to assist in achieving sustainable outcomes. (CoPP, 2011; LG, pers comms. 13 June, 2019)

Key: Desktop Research (prior interviews) | Interviewee Input | Post Interview Research

		access those. (LG, pers comm. 14 June, 2019, 2019)	understanding, skills and commitment to manage stormwater within an integrated water management approach. (Melbourne Water, 2019) • Planning discussions about Fishermans Bend floor area increase for delivery of public infrastructure works. However not confirmed. (LG, pers comms. 13 June, 2019)	innovative approaches that make fit-for-purpose insurance affordable to people in Melbourne. (Resilient Melbourne, n.d.) • ***Design and Development Overlay 10:*** A result of C270 Planning Scheme Amendment (State Government) put in place to allow floor area uplift in exchange for provision of public benefit including publicly accessible open space (DELWP, 2019d; LG, pers comm. 14 June, 2019) **City of Port Phillip** • ***Sustainable Design Strategy 2011 –*** Waiving of planning permit fees for rainwater tanks and grey water systems. (CoPP, 2011)
Public Relations (eg. guidelines, demonstration projects, ecological labels, media and awareness)	• ***Australian Green Building Council - Green Star Communities Rating 2016:*** Assess the planning, design and construction of large-scale development projects at a precinct, neighbourhood and/or community scale for governance, liveability, economic prosperity, environment and innovation. (Australian Green Building Council, n.d.; WR, pers comms. 12 June, 2019) • ***National Water Quality Management Strategy (NWQMS) 2018:*** *The Strategy is a voluntary, nationally coordinated framework to facilitate water quality management. It consists of nationally agreed policies, guidelines and tools to assist governments, and other organisations and institutions, to manage water quality, taking account of local conditions and community values It includes guidelines for recycled water use and stormwater harvesting. (Australian Government, 2018)*	• ***Environment Protection Authority – Maintaining Water Sensitive Urban Design Elements Guidelines 2008*** (Environment Protection Authority Victoria, 2008) • ***Water Sensitive Urban Design Guidelines – Melbourne Water 2013*** (Melbourne Water, 2013) • ***Growing Green Guide: A guide to green roofs, walls and facades in Melbourne and Victoria 2014: D****eveloped by the then Inner Melbourne Action Plan Councils of Melbourne, Port Phillip, Yarra and Stonnington and the State Government of Victoria.* (Green Growing Guide, 2014; WR, pers comm. 12 June, 2019) • ***Apartment Design Guidelines for Apartment Buildings Victoria 2017:*** An apartment buyers and renters guide is planned along with a training program for planning and building design practitioners. (DELWP, n.d.) • ***Water Sensitive Urban Design Guidelines – Clearwater 2018*** (Clearwater, 2018) • ***Draft Blue- Green Guidelines:*** Prepared by Melbourne Water and DELWP to guide Councils. (LG, pers comm. 14 June, 2019)	• ***Fishermans Bend Vision 2016:*** Prepared by the Fishermans Bend Taskforce, it sets out the future development of Fishermans Bend up to 2050 and is informed by consultation on the Recast Vision. The Recast Vision was a response to a recommendation to expand, refresh and redefine the vision using the Fishermans Bend Urban Renewal Area Draft Vision 2013 as a foundation. (Department of Jobs, Precincts and Regions, 2019) • ***Integrated Water Management Forums 2018****: a platform for identifying interest areas and collaborative projects between local governments, water corporations, catchments management authorities and other important stakeholders (LG, pers comm. 11 June, 2019)* • ***Fishermans Bend Integrative and Innovative Water Management 2018:*** Prepared by Ramboll consultants, who were engaged by CRC Water Sensitive Cities and undertook a WSUD strategy for the whole precinct. GHD consultants developed a strategy that provided more traditional drainage solutions including pipes. The final strategy was a mix of both approaches. (LG, pers comm. 11 June, 2019)	**City of Melbourne** • Working with DELWP to progress the action in their Climate Change Adaptation Plan to host a forum on managing climate-related insurance risks. (CoM, 2017a) • Funding Australian Research Council and Cooperative Research Centre projects to further research into green roofs, walls and facades. (CoM, 2017b) • Partnered on demonstration green infrastructure projects including Green Your Laneway and Green Our Rooftop.(LG, pers comm. 14 June, 2019) • Developing and continuing Australia's first quarterly green roof forum – Canopy: Melbourne's Green Roof Forum. (CoM, 2017b) **City of Port Phillip** • **Guidance publications:** Rainwater Tank Maintenance Manual; Raingarden Maintenance Manual and Porous Paving Maintenance Manual • **Compliance Guidelines for Clause 22.12 Stormwater Management:** provides advice on the implementation of *Planning Policy Clause 22.12 Stormwater Management (Water Sensitive Urban Design)*. (CoPP, 2014; LG, pers comms. 13 June, 2019) • **CoPP WSUD Guidelines Applying the Model WSUD Guidelines (An Initiative of the Inner Melbourne Action Plan)** (CoPP, n.d.b); LG, pers comms. 13 June, 2019) • ***Smart Solutions for Apartments Initiative:*** In partnership with owners' corporations, facility managers and landlords the Council has 10 sustainability showcase buildings representing a range of building types (eg. mid-rise and high-rise) and a broader behaviour change initiative to provide support, networking and advice. (Sustainable Port Phillip, 2019) • **Active member and partner of the Council Alliance for a Sustainable Built Environment (CASBE):** A collection of Victorian municipal governments working towards sustainable built environments. (CoPP, 2011) • Sponsor and member of the Green Building Council Australia. (CoPP, 2011) • Education and Engagement: including community factsheets, ESD Factsheets, a community environment E-hub website for design, DIY, good links and resources; facilitating sustainable design workshops and forums on rebates; and showcase innovative sustainable design solutions. (CoPP, 2011)

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Fishermans Bend, St Kilda (CoM and City of Port Phillip) – Stakeholder and Planning Instrument Map

Key: Desktop Research (prior interviews) | Interviewee Input | Post Interview Research

Table 2– Key Stakeholder Mapping

Local Planning Instruments		Relevant Actors and Stakeholders	Representation	Role
Formal	**Mandates**	Victorian DELWP (DELWP)	Victorian State Government Department	Key departmental body for planning and water development regulations in Victoria. The water division manages groundwater, catchments and waterways, infrastructure, water saving and re-use projects, flood management, governance and water legislation, in partnership with a network of government agencies and water authorities. (Department of Jobs, Precincts and Regions, n.d.c) The following bodies have been established for the Fishermans Bend precinct: • Stormwater Management Advisory Committee Established by the Minister for Planning in 2018 to provide independent advice on planning and development controls for improving stormwater management and strengthening the links between water management and urban planning. The Committee submitted its report to government in September 2018 with 18 recommendations. Two of the most critical reforms were implemented in October 2018 to expand stormwater obligations to most development types in the Victoria Planning Provisions and to include an IWM clause in the Planning Policy Framework. A government response to the Committee's report is currently being prepared and $1.5m was allocated in the 2019-20 State budget to help implement stormwater management reforms. (DELWP, n.d.a; WR, pers comm. 12 June, 2019) • Fishermans Bend Planning Review Panel Conducted public hearings from 1 March to 22 June 2018 on the planning scheme amendment for Fishermans Bend. (DELWP, n.d.a) • Fishermans Bend Standing Advisory Committee Established to assess the 26 projects called in and frozen by the Minister for Planning in February 2018, to consider and provide advice on proposals for site-specific planning controls within the Melbourne and Port Phillip Planning Schemes, to facilitate redevelopment. (CoPP, n.d.c) • Fishermans Bend Development Board Guides the planning and development of this project and is supported by the Fishermans Bend Taskforce. (Department of Jobs, Precincts and Regions, 2019)
		Victorian Department of Jobs, Precincts and Regions	Victorian State Government	Established the Fishermans Bend Taskforce in January 2016 to lead the planning of the area, and comprises members from the DELWP, the CoM, the CoPP and the Victorian Planning Authority. The Taskforce will work together with the Development Board towards delivering four detailed neighbourhood plans for Lorimer, Montague, Wirraway and Sandridge, a Fishermans Bend Employment Precinct Plan, overarching Infrastructure Plan for the entire Fishermans Bend area, including transport infrastructure, community infrastructure and open space, environment and water sensitive urban design responses and development contribution and a draft planning scheme amendment and any proposed implementation actions arising from the development of the plans. (Department of Jobs, Precincts and Regions, 2019) The Taskforce developed the policy for the renewed Framework which replaced the Strategic Framework Plan in 2016 and introduced most of the key current strategic directions and the 8 sustainability goals, the 10 strategic directions (no.8 is Sustainable & Resilient Place). (WR, pers comm. 12 June, 2019)
		Melbourne Water Corporation (MW)	Victorian State Government	State-owned metropolitan bulk water and sewerage company that are the flood plain managers of western Port Phillip Bay, including polluted water treatment and drinking water with responsibility for metropolitan scale infrastructure that is greater than 60Ha in area. (LG, pers comms. 13 June, 2019) Special Building Overlays are the primary flood control system utilised by the Corporation (i.e. for main roads & waterways under SBO 1/3) and local government level (i.e. for local roads under SBO2). (WR, pers comm. 12 June, 2019)
		South East Water (SEW)	Water Retailer	Water retailer, providing drinking water, sewerage, trade waste and recycled water services to customers, and approval for connections to water network using Conditions of Connection. This includes consideration of Fishermans Bend's additional rainwater harvesting and stormwater retention/detention requirements. Also develops precinct-based projects and integrated water management plans. (WR, pers comms. 12 June, 2019; WR, pers comm. 12 June, 2019)
		CoPP (COPP)	Local Government	Works across the municipality and is responsible for drainage, implementing and managing alternative water supply projects, including management of water capture, storage and reuse and water usage. They assess local drainage infrastructure within the Wirraway, Sandridge and Montague precincts for buildings up to 8 storeys. (LG, pers comms. 13 June, 2019, 2019) They specify some integrated water management permit and non-permit conditions that require SEW and/or MW permission. (WR, pers comm. 12 June, 2019)
		CoM (COM)	Local Government	Works across the municipality and is responsible for drainage, implementing and managing alternative water supply projects, including management of water capture, storage and reuse and water usage. They assess local drainage infrastructure within the Employment and Lorimer Precincts for buildings up to 12 storeys. (LG, pers comm. 11 June, 2019, 2019) They specify some integrated water management permit and non-permit conditions that require SEW and/or MW permission. (WR, pers comm. 12 June, 2019)
Informal	**Financial Incentives**	South East Water (SEW)	Retailer	Water retailer undertaking research and commercial development of integrated water management technologies such as Tank Talk ® through its arm IOTA Services Pty Ltd. (WR, pers comms. 12 June, 2019)
	Public Relations	Places Victoria	Victorian State Government	It is the Victorian Government's property development agency delivering urban renewal. In September 2013 Places Victoria released the Draft Vision and led a consultation process to seek feedback on the Draft (CoPP, n.d.c).
		Education institutions	Education	Education of water initiatives and research partnerships eg. Monash University and University of Melbourne (LG, pers comm. 14 June, 2019)
		Professional and research institutions and peak bodies	Industry Bodies	Promotion and awareness of projects amongst industry professionals. eg. Cooperative Centre for Research of Water Sensitive Cities, Clearwater, Stormwater Australia, Vic Stormwater, Australian Green Building Council, Australian Water Association. (LG, pers comm. 11 June, 2019)

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Fishermans Bend, St Kilda (CoM and City of Port Phillip) – Stakeholder and Planning Instrument Map

Key: Desktop Research (prior interviews) | Interviewee Input | Post Interview Research

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APPENDIX E – Interview Findings – Additional Factors

Key: Initial List for Discussion (prior interviews) Interviewee Input

Revised Table 3 – Additional Factor Mapping of persistent barriers and drivers for implementation of Water Sensitive Urban Design (WSUD)

Influential Factor Categories	Type		Type	Description
	Barrier	Driver		
Economic	X		City Government's Budget	Allocated, restricted and silo resourcing of finances by different departments.
	X		Investment Cost	Costs associated with WSUD investment and construction including land value, materials and labour.
			Insurance Costs	Costs associated with flooding or stormwater damage.
			Market Swing	Change in value eg. Land, real estate, technology prices etc.
	X	X	Maintenance Cost	The planning of the asset accounting for ongoing and long-term maintenance for optimum use.
			Profit Margin Pressure	Influence of saleability and flow-on costs to developers and investors.
Environmental		X	Climate Change	Promotion of adaptation and mitigation measures to reduce climate disturbances.
			Ecosystem Services	Promoting the benefits of biodiversity, infiltration and recreation of areas.
			Environmental Protection	Protection of natural environmental quality of an area.
		X	Flood Risk	Likelihood of a flood occurrence.
		X	Multi-Benefits	Aesthetic and functional delivery of assets for the environment and community eg. Road renewal and rain garden.
	X		Pollution	Disturbance or improvement to the quality of water.
			Protected Landscape	Limitations and restrictions to the development of land, such as heritage conservation.
			Urban Cooling	Reduction of hard surfaces heat retention in urbanised areas.
			Urban Densification	A lack of available space for WSUD.
Institutional		X	Collaboration	Cooperation in delivering an outcome.
	X		Commitment	Dedication to decisions.
			Consultation (bottom-up)	Timely involvement of key stakeholders, including relevant authorities and citizens.
	X	X	Entrepreneurial	A lack of precedent, may cause intervention by other organisations or departments.
	X		Expertise	Knowledge of WSUD and its implementation requirements. Eg. Capacity of planning assessment staff in their assessment of the measure.
			Leadership	Organisational change and its influence on stability and consistency of project personnel and project champions.
	X		Knowledge Transfer	Information sharing between administrative professionals to support WSUD adoption.
	X		Policy Integration	Consistent policy and plan-making. i.e. responsive and reciprocal
	X	X	Political will (top-down)	Support or lack of support for prioritisation of decentralised technologies.
	X		Priority	Hierarchy of performance goals and deliverables, which questions Priority legitimacy of the system.
	X		Private Sector Influence	Power of private players in outcome i.e. dominant or dormant
		X	Procedure Time	Lengthy or efficient administrative processes to approve WSUD.
			Procedure Legitimacy	Legitimate processes for tender and contract procurement.
	X		Responsibility	Ongoing management of assets for optimum working condition.
	X		Silo Resourcing	Isolation of organisational and resource flows.
			Workload	Capacity of administrative staff to support WSUD.
Social			Adversity to Change	Uncertainty about new technology transferability.
	X	X	Awareness	Knowledge of WSUD and its implementation benefits.
			Acceptance	Knowledge and agreement of technology and its implementation benefits. i.e. water literacy
	X	X	Environmental Stewardship	Care for ecosystem services and its functioning.
			Ownership	Support, advocacy and responsibility for technology after its implementation.
Technical	X		System Functionality	Ability of WSUD to maintain its intended function.
			Adaptability	Flexibility of WSUD to change to new requirements.
			Efficiency	Smart and competitive delivery in a commercialised environment.
	X		Replication	WSUD design response to unique site conditions. Eg. Rain gardens and required soil drainage properties.
			Resilience	Flexibility of WSUD to withstand external pressure.
			Vulnerability	Robustness of WSUD performance.
	19	8		

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