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Abstract

With increasing worldwide recognition of the influence of urban development on the hydrological functions of water, there is growing pressure for urban planning to play a greater role in water resources management in urban regions. Planning for green open spaces in particular can play an important role, as they have the potential to contribute to sustaining ecosystem services that assist flood management. It has been argued that interconnected and strategically planned networks of green open spaces should be planned for early in landuse planning and design processes, with consideration of water-related ecosystem values and landscape functions in concert with land development, growth management and built infrastructure planning. Although there is growing recognition of the importance of green open space planning for water sensitive cities and supportive planning measures, there are few analyses of the actual inclusion of this recognition in plans and strategies, or the presence of related actions and planning mechanisms. This paper addresses this gap by comparatively analysing the approaches taken to regional green open space planning in three Australian capital city-regions. Findings indicate the acknowledgement of relationships between flood regulation and green open space planning and various associated planning mechanisms. However, there is limited explicit integration of flood management and green open spaces planning, and significant on-ground barriers to enabling this integration to occur given the legacy of past planning decisions and the lack of information to support implementation. The paper concludes with recommendations for further research to assist planning for green open spaces as an ally to ecosystem services relating to flood management.

Keywords	Water management; ecosystem services; regional planning; flood regulation; catchment
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Response to Reviewers Comments second round-final [2].docx [Response to Reviewers]

Water in the city 2nd revision-final [2].docx [Manuscript (without Author Details)]

Appendix 1-final.docx [Figure]

WSC case study regions.tif [Figure]

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Reviewers Comments	Response of Authors	page reference
<p>The Author's dismissal of the work published at http://urbanwatercyclesolutions.com as "not peer reviewed" is profoundly incorrect and represents a return to the CRC/Water Bureaucracy agenda - the independent public reports did not suit the inertia agenda & science vested interests at the time which resulted in a range of claims. All articles published on this website have been extensively peer reviewed or are based on peer reviewed publications.</p>	<p>Rather than dismissing this work, we have included a reference to a document found on this website (Coombes, P., Want, S. & Colegate, M. Development of policies for water cycle reform in greater Melbourne and Sydney). We thank the reviewer for this suggestion. We reiterate that we have no agenda. The website is for a consultancy firm, and while we are happy to use any academic literature found through the site, we do not wish to reference the website itself.</p>	<p>Page 14, last paragraph of section 5.3.</p>
<p>Otherwise the discussion resonated with the reviewers experience of these processes and proved to be an enjoyable and worthwhile reading exercise. This paper should definitely be published and it will now make an important contribution in its current form when corrected to include the actual science underpinning the Living Victoria work.</p>	<p>Thank you for recommending publication.</p> <p>We thank the reviewer for referring us to papers that have addressed some of the scientific groundwork to some policy documents. We have improved our paper with suggested references such as Coombes and Roso 2015, Coombes 2015, Coombes and Barry 2014.</p> <p>Please note that our document analysis identified Office of Living Victoria documents, and their merits of acknowledging the importance of green space for flood management. These OLV documents represent a portion of the documents included in the Melbourne case study and are representative of a small part of our analysis. Future papers that focus on shorter time periods and fewer policy documents would lend</p>	<p>pages 9, 10, 11</p> <p>See especially section 5.1</p>

	<p>themselves better to in-depth analyses of the processes of gathering evidence to base policy decisions on.</p> <p>We do not feel that 'including the science' underpinning these documents is relevant as there is not space to discuss the scientific merits (or otherwise) of each document – this is beyond the scope of our analysis.</p>	
<p>There are some small gaps in understanding or discussion of the policy-strategy-statutory planning interactions – they are all actually linked. Dominant firm oligopoly processes with associated rent seeking behaviours impact on this bargaining problem (which are alluded to by the authors) which explains some of the lack of progress. Similar to the economic issues, all planning schemes are driven by a hope to alter local land use behaviours to achieve outcomes at different planning scales – the discussion could have more clearly made these important links in planning scales: for example the objectives of a planning policy or scheme may be articulated at a regional scale but require intervention at other scales to achieve multi-objective planning (land use policy) objectives.</p>	<p>We have re-enforced the problem of scale (also included in section 3.3, page 7) in advancing policies based on the whole-of water cycle issues in the conclusion.</p>	<p>pages 7, 15 & 16</p>
<p>These scale and economic issues are probably the topic of future consideration and endeavour by the authors. This paper should be the start of a scientific conversation about the value of green spaces for management of flooding and protection of ecosystems. The paper is very well driven – a handful of minor grammar correction should further enhance the reading experience.</p>	<p>We agree that this paper represents the start of a conversation.</p> <p>We have gone through the manuscript once more and made minor corrections.</p> <p>Thank you for your support and contributions to improve our manuscript.</p>	

Water in the city: Green open spaces, land use planning and flood management – an Australian case study

Abstract

With increasing worldwide recognition of the influence of urban development on the hydrological functions of water, there is growing pressure for urban planning to play a greater role in water resources management. Planning for green open spaces in particular can play an important role, as they support important ecosystem services, including those that assist in flood management. It has been argued that interconnected and strategically planned networks of green open spaces should be planned for early in land use planning and design processes, with consideration of water-related ecosystem values and landscape functions in concert with land development, growth management and physical infrastructure planning. Although there is growing recognition of the importance of green open space planning for water sensitive cities and supportive planning measures, there are few analyses of the actual inclusion of this recognition in plans and strategies, or the presence of related actions and planning mechanisms. This paper addresses this gap by comparatively analysing the approaches taken to regional green open space planning in three Australian capital city-regions. Findings indicate the acknowledgement of relationships between flood regulation and green open space planning and various associated planning mechanisms. However, there is limited explicit integration of flood management and green open spaces planning, and significant on-ground barriers to enabling this integration to occur given the legacy of past planning decisions and the lack of information to support implementation. The paper concludes with recommendations for further research to assist planning for green open spaces as an ally to ecosystem services relating to flood management.

Keywords

Water management; ecosystem services; regional planning; flood regulation; catchment

Highlights

- Analysis of flood-related ecosystem services in regional planning of green open spaces
- Benefits of green open spaces for flood management are seldom explicitly acknowledged
- There is a lack of detailed planning actions to support flood-related ecosystem services
- Limited science-based reasoning in policy to support open space planning for flood management
- Improved insight on how land use patterns affect flood-related ecosystem services is needed

1. Introduction

In many metropolitan areas worldwide, urban expansion and population growth coupled with climate change is resulting in costly flood management challenges (Keath and Brown 2009, Jha, Bloch et al. 2012). Metropolitan regions can be particularly vulnerable to devastating impacts of flood where human settlements expand into vulnerable areas and where urban

development alters the water balance of metropolitan regions (Vorosmarty, Leveque et al. 2005). It is argued that impacts of floods are increasing in many regions globally, demanding appropriate management of ecosystems to assist in flood management (Bravo de Guenni, Cardoso et al. 2005).

Legacies from past planning decisions and water infrastructure have greatly altered hydrological functions of urban areas, and also reduced areas of green open space to small fragments that are geographically disconnected from each other (Donofrio, Kuhn et al. 2009). For example, increased impervious surfaces, filling of wetlands and development on floodplains to accommodate population growth has resulted in frequent flooding in many of Australia's earlier settlements (Coombes and Roso 2015). To address these issues, there is now a rising interest globally in the role of carefully planned networks of green open spaces to achieve greater resilience to flood (Carmon and Shamir 2010, Ashley, Nowell et al. 2011, Ellis 2013, Demuzere, Orru et al. 2014, Lennon, Scott et al. 2014).

Additionally, the role of ecosystem services to improve environmental outcomes in urban regions is increasingly recognised (Niemelä, Saarela et al. 2010, Hansen and Pauleit 2014). Ecosystem services derived from green open spaces that relate to flood management most closely fit the description of 'regulating' services, although green open spaces also have implications for a range of cultural and provisioning ecosystem services that relate to urban water management (Mirza, Patwardhan et al. 2005, De Groot, Alkemade et al. 2010).

Although the role of carefully planned networks of green open spaces in contributing to flood management has been documented, there is a dearth of policy-driven overviews looking holistically at the ways in which ecosystem features can be managed to reduce vulnerability to floods (Depietri, Renaud et al. 2012). Additionally, there are few analyses of the inclusion of considerations of the potential for ecosystem services derived from green open spaces to contribute to flood management in plans and strategies in growing metropolitan regions, or of related planning mechanisms (De Groot, Alkemade et al. 2010, Andersson, Barthel et al. 2014).

This paper aims to improve our understanding of how urban and regional planning supports green open space planning for improved water resources management, with a particular focus on flooding and related ecosystem services. This paper starts by identifying attributes of green open spaces relevant to ecosystem services beneficial to flood management, and related planning approaches suggested in literature. This is followed by a description of the framework used to review the approaches taken in the Australian metropolitan regions of South East Queensland (SEQ), Melbourne and Perth. The planning documents reviewed along with the methods used to extract relevant data are then presented, followed by the results of the evaluation. The paper finishes with a discussion of main findings and some recommendations to facilitate planning for green open space as an ally to flood management through the maintenance of ecosystem services.

2. Planning for green open spaces to aid flood management

2.1 The role of green open spaces in aiding flood management

Floods can be naturally occurring phenomena that benefit ecosystem health (Mirza, Patwardhan et al. 2005). However, human activities can reduce the capacity of ecosystems and soils to absorb excess water and attenuate floods (Bravo de Guenni, Cardoso et al. 2005, Vorosmarty, Leveque et al. 2005, Coombes and Roso 2015). Population growth and settlement preferences also strongly influence the regulation of floods, the expansion of human settlements onto floodplain areas being a common cause for increased vulnerability to

flood impacts in human settlements (Bravo de Guenni, Cardoso et al. 2005, Mirza, Patwardhan et al. 2005).

Efficient transport of runoff from impervious surfaces in urban settlements by piped stormwater drainage systems have generally resulted in urban streams that exhibit a flashy hydrograph, elevated concentrations of nutrients and contaminants, altered channel morphology, and reduced biotic richness (Meyer, Paul et al. 2005, Walsh, Fletcher et al. 2005, Haase and Nuisl 2007). The accompanied decreased infiltration, increase in surface runoff, and reduced baseflow discharge in urban streams often leads to increased risks of flash flooding (Haase and Nuisl 2007) and reduced potential for groundwater recharge (Hough 1995, Paul and Meyer 2001, Walsh, Fletcher et al. 2005). These consequences are especially likely where impervious surfaces are directly connected to urban streams (Walsh, Fletcher et al. 2005) and are related to a range of other factors such as the spatial pattern of land conversion, and the previous quality of converted land (Haase and Nuisl 2007).

In this paper, green open space is defined as space that is dominated by a 'natural' environment and characterised by ecosystem and landscape values, as opposed to a built-up environment with a higher degree of intervention in ecosystem and landscape processes (Maruani and Amit-Cohen 2007). This definition includes a range of different land uses such as agricultural and conservation areas through to greenways and green belts or corridors, and constructed and natural wetlands (Bengston, Fletcher et al. 2004, Bomans, Steenberghen et al. 2010).

The literature highlights the role of green open spaces and inherent ecosystem services in aiding flood management and mitigation. Key attributes of green open spaces that have implications for flood management and mitigation include their potential capacity to prevent disturbance caused by floods through to flood regulation (Millennium Ecosystem Assessment 2005). Green open spaces can contribute to flood regulation through increased soil permeability, which leads to reduced surface runoff and peak stream flows (Bravo de Guenni, Cardoso et al. 2005, Gill, Handley et al. 2007, Kaźmierczak and Cavan 2011, Ellis 2013). Green open spaces can also provide storage capacity for floodwaters in urbanized areas (De Groot, Alkemade et al. 2010), while riparian vegetation helps to reduce stream bank erosion during flood events (Tubman and Price 1999). These functions are also performed by corridors and networks of green open spaces that incorporate stormwater infrastructure alongside or adjacent to water bodies (Gill, Handley et al. 2007, Handley 2007, Wheeler and Evans 2009, Ellis 2013), which can be used as surface flow pathways, providing water storage and retention areas at times of high water flow. Site vegetation and neighbourhood riparian corridors can also reduce runoff from low intensity, short duration rainfall events (Ellis 2013).

Green open spaces retained in upstream catchment areas help maintain streamflow and reduce peak streamflow in lower parts of the catchment (Sinai et al 2006 in Carmon and Shamir 2010). Inland water components such as natural and constructed wetlands, floodplains, lakes and reservoirs can assist flood attenuation through increasing residence time of rivers, reservoirs and soils (Bravo de Guenni, Cardoso et al. 2005, World Resources Institute 2005, Demuzere, Orru et al. 2014). These flood regulating services clearly justify attention paid to green open space planning in the context of ecosystem services that contribute to flood management.

In addition to these flood regulating attributes, water sensitive urban design (WSUD) structures (such as rainwater tanks, bio-retention swales and basins, constructed wetlands, and stormwater harvesting and storage) in green open spaces can reduce stormwater runoff volumes and peak flows at site level (Barton and Argue 2007, Coombes 2009, Walsh, Fletcher et al. 2012). WSUD and water sensitive urban development are based on approaches

that seek to integrate urban water systems with the water systems found in the natural hydrological cycle (Barton and Argue 2007). This includes considering impacts of urban water services on catchment ecosystems (Sharma, Cook et al. 2012). The particular tools to achieve integrated water sensitive urban design will vary depending on stakeholder and site-specific factors (Sharma, Cook et al. 2012). The effectiveness of WSUD features in green open spaces for flood attenuation increases at a catchment scale when they are combined with a range of other decentralised storage and infiltration approaches (Grose and Hedgcock 2006, Mell 2008, Davis, Hunt et al. 2009, Ellis 2013, Demuzere, Orru et al. 2014).

In choosing to focus on the planning of green open spaces and ecosystem services for flooding, we acknowledge that this is one aspect of a range of different actions that may relate to water sensitive planning and integrated urban water management, and that due to the connected dynamic movements of water through urban regions specific water management issues (such as flood management and planning for green open spaces) are intrinsically connected and difficult to separate from a range of other water management issues and actions. Nonetheless, green open spaces (Benedict and McMahon 2002, Keeley, Koburger et al. 2013), flood management (Godden and Kung 2011) and ecosystem services (Liu, D. Crossman et al. 2013) are crucial aspects in the shift to total water cycle management that need to be mainstream in policy (and planning initiatives) (Ellis 2013). These are concepts and ideas that have received significant attention in applied science (Lennon, Scott et al. 2014) and some practice internationally (Ashley, Nowell et al. 2011), but potentially remain experimental and limited within policy.

2.2 Enabling the implementation of green open spaces

Accompanying the rising interest in the role of carefully planned green open spaces to achieve flood regulation and other ecosystem services, are a number of planning measures and concepts that seek to accommodate surface water rather than exclude it. There is increasing evidence that such measures, often proposed under headings of green infrastructure, WSUD, and/or low impact development (LID), can contribute to flood regulation (Fletcher, Shuster et al. 2015) through the maintenance of ecosystem services in green open spaces (Demuzere, Orru et al. 2014).

In response, a number of urban planning approaches seeking careful placement of green open spaces in accordance with the natural hydro-geographic layout have emerged over the last decade (Carmon and Shamir 2010, Porse 2013). These approaches can alleviate pressures on underground drainage networks and reduce risks of sewer and stormwater flooding through capturing and infiltrating urban runoff in consideration with the natural stream system (Carmon and Shamir 2010). However, the capacity of green open spaces to regulate flooding may be limited in severe meteorological events (Depietri, Renaud et al. 2012). In addition, it is important to acknowledge that simplistic panaceas or blueprints will be insufficient to address the complex issues associated with ecosystems services relating to flood management that are derived from green open space, and planning has to be suitable for specific localities (Ferguson, Frantzeskaki et al. 2013).

One of the emerging urban planning approaches seeks to avoid development of urban settlements in floodplains, leaving them as green open spaces with designated land uses (such as agriculture and recreational areas) that may be temporarily suspended during flood periods with acceptable losses (Carmon and Shamir 2010). A second approach relates to the placement of green open spaces alongside, or close to urban streams, with multi-functional attributes such as providing active transport corridors, recreational areas, amenity, and habitat (Flink 2002, Gill, Handley et al. 2007, Carmon and Shamir 2010).

Finally, there have been calls for planning for interconnected and strategically planned networks of green open spaces to occur early in land use planning and design processes, with consideration of ecosystem values and water-related landscape functions (Benedict and McMahon 2002, Carmon and Shamir 2010). In particular, it is argued that such early planning could facilitate the development of networks of multi-functional green open spaces in concert with land development, growth management and physical infrastructure planning (Benedict and McMahon 2002, Carmon and Shamir 2010). Planning approaches that address the whole water cycle and landscape scale in a holistic manner (McCallum and Boulot 2015), and that integrate land use planning (including green open space planning) and water resource management are sought to facilitate the aims described above (Brown, Farrelly et al. 2009, Gain, Rouillard et al. 2013), as fragmented and piecemeal approaches have been cited as common challenges in achieving water resource management goals (McCallum and Boulot 2015).

Hence, there is substantial evidence that green open spaces can provide ecosystem services to support flood management and that land use planning has a key role to play in implementation of green open space strategies within urban areas. Nonetheless, there is limited evidence of green open spaces being considered within planning as a key part of flood mitigation. This study applies a case study approach to investigate how green open space is currently incorporated into land use planning, how flood management ecosystem services are considered and what opportunities and limitations there are to implementing green open space as a flood strategy.

2.3 The Australian context

In very general terms, Australian catchments experience typically more extreme and frequent peak flows, lower base flows, and longer and more variable dry periods than European and North American catchments (Croke and Jakeman 2001). Flood risks in many Australian urban catchments have increased due to changes in land use, climate change, increased density of urban areas, and reduced hydraulic capacity of aged drainage networks (Coombes and Roso 2015). Traditionally, flood management has largely relied on rapid discharge and accumulation of stormwater via drainage infrastructure and conveyance to lower parts of urban catchments. However, this has transferred adverse impacts of heightened flood risks and reduced health of waterways in lower catchment areas (Coombes and Roso 2015).

Since the 1970s, many important water policy reforms in Australia have resulted from challenges experienced during periods of drought or flooding, as extreme weather events highlight the unviability of continuing traditional approaches to water management. The 1990s in Australia saw efforts to introduce WSUD and Integrated Water Cycle Management (IWCM) approaches in urban water management (Coombes 2015, Fletcher, Shuster et al. 2015). In 1995, the publication of the WSUD guidelines in Western Australia formalised the movement towards design and planning approaches for urban settlements that included concerns such as water conservation, waterway protection and stream health, and stormwater quality with town planning processes (Daniell, Coombes et al. 2014).

National guideline documents encourage urban drainage solutions to be integrated with planning schemes and a range of environmental and social concerns (Engineers Australia 2006, Coombes and Roso 2015). Major floodway and flood-related development controls in Australian urban centres are principally controlled by state-based legislation (Godden and Kung 2011), and influenced by state and territory guidelines for best practice urban stormwater management (Barton and Argue 2007). Responsibility for implementing stormwater management mainly lies with local governments, who play a critical role in stormwater management and land use planning and therefore are integral in managing the urban water cycle (Coombes, Smit et al. 2015).

Water management in Australia has evolved over the past two decades (Godden and Kung 2011). Urban designs are now encouraged or mandated to manage urban stormwater impacts 'at source' (Argue in Coombes 2015), and maintain water in landscapes and soil profiles (Coombes 2015). This capturing and retention of stormwater at or near sources of runoff generally contributes to reduced flood frequency through decreased stormwater peak discharges (Roy, Wenger et al. 2008, Coombes and Barry 2014 in Coombes 2015, Coombes and Roso 2015). However, Coombes & Barry (2014) argue that the placement of urban catchment measures such as retarding basins, constructed wetlands and stormwater harvesting devices in Australia has typically been in lower catchment areas, resulting in missed opportunities to reduce flood risks and benefit waterway health higher up in urban catchments.

Importantly, it has been argued that despite policy developments, urban developments designed with integrated water management concepts and WSUD measures remain novel in comparison with conventional approaches (Barton and Argue 2007, Sharma, Cook et al. 2012). Urban water professionals surveyed in a study by Sharma et al. (2012) considered WSUD policies and guidelines to be inconsistent across levels of government. This was considered to result in a lack of clarity, resulting in discouraging water sensitive developments (Sharma, Cook et al. 2012). There have been many calls for policy frameworks that integrate land use planning and water and flood management at local and regional scales (Brown 2005, Wong and Brown 2009, Godden and Kung 2011, Sharma, Cook et al. 2012), and that correspond with urban renewal and asset renewal processes (Coombes 2015). Godden & Kung 2011 (2011) argue that water policy reforms in Australia have mainly focused on water scarcity and environmental protection rather than adapting to flood risk, and that relatively little research has explored changes in systems of law needed to respond to growing risks of flood.

3. Research approach

3.1 Case Study Areas

This research takes a case study approach (Flyvberg 2006) to offer examples of highly urbanised systems that require a greater understanding of their dependence and impact on water resources at the metropolitan-region scale. Three Australian case study areas have been selected as the subject for this evaluation: the SEQ region in Queensland, the Melbourne Metropolitan region in Victoria, and the Perth Metropolitan region in Western Australia (see Figure 1).

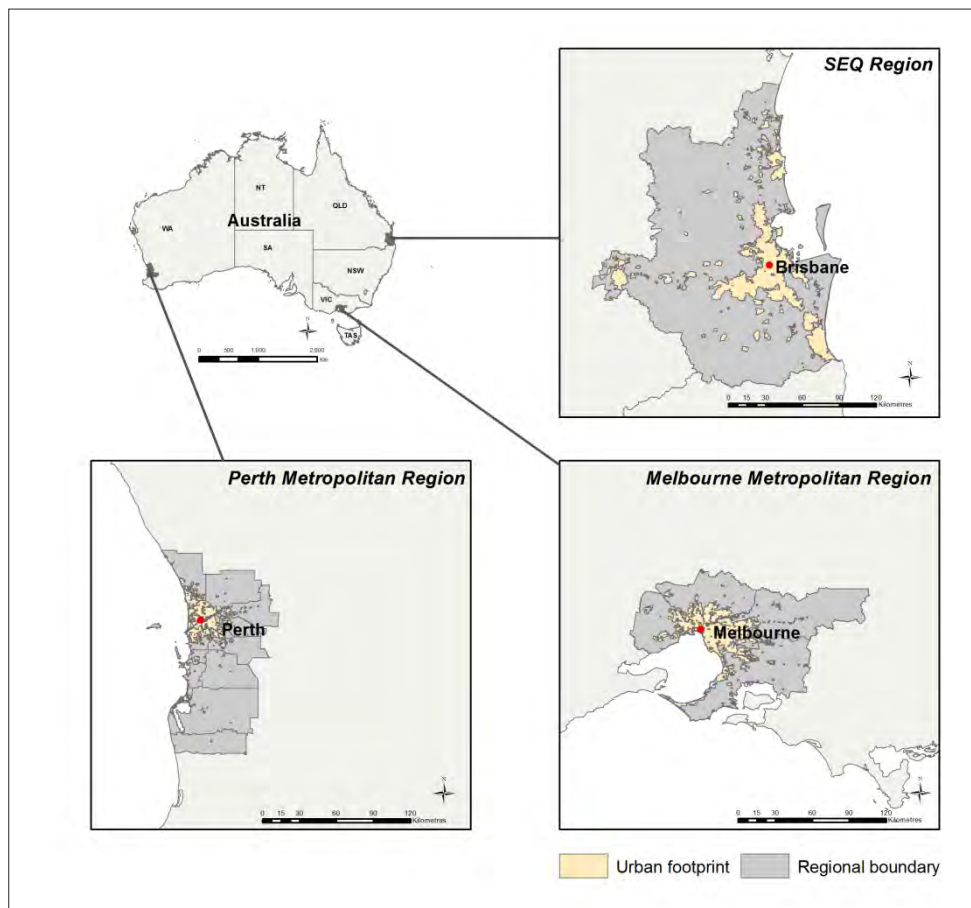


Figure 1. Australian Metropolitan Case Study Regions

These areas are highly urbanised capital cities in their respective states, and like many metropolitan regions worldwide are rapidly growing and face recurrent climate extremes such as floods and droughts that are likely to be exacerbated by climate change (Reisinger, Kitching et al. 2014, McCallum and Boulot 2015). These factors alone provide the imperative for exploring new approaches to the way in which these city-regions are planned and managed, including from a green open space planning and water and flood management perspective. Additionally, because each of these regions has distinct precipitation patterns, and jurisdictional and institutional arrangements for land use planning and water management, this study provides scope for comparing different approaches to incorporating considerations of flood and ecosystem services in green open space planning. A summary of the characteristic of each region is provided in Table 1.

Table 1. Overview of case study areas

Feature	SEQ	Melbourne	Perth
Population	3 M (Australian Bureau of Statistics 2012)	4.1 M (City of Melbourne 2015)	1.65 M (Western Australian Planning Commission 2010)
Flood management	Responsibility of local governments based on specific flood hazard studies and implemented	State-wide flood policy, with attributed responsibility to regional agencies (Catchment	State government provides advice on flood management and assistance for preparing flood

	by local planning schemes (Department of Local Government and Planning 2014).	Management Authorities and Melbourne Water) to manage regional flood issues, and local governments to manage local flood issues (Department of Environment n.d.)	management plans to guide land use planning and development. Local governments have the responsibility for implementing flood management plans (Department of Water n.d.).
Urbanisation process	Floodplain areas progressively converted from agriculture to urban residential and commercial uses (Head 2014).	Located along the lower stretches of the Yarra River placing considerable strain on waterways, drains and floodplains (McCallum & Boulot 2015).	Central business district is surrounded by the Swan River to the south and east, with the rest of the city mostly located on a sandy and flat coastal Plain (McCallum & Boulot 2015).
Availability of green open spaces	Population growth largely accommodated through greenfield development reducing amount of public green open space per person (Department of Environment and Resource Management 2009, Queensland Government 2013) Competing pressures on green open spaces to accommodate future population growth, particularly remaining natural vegetation being earmarked for future development.	Established suburbs have relatively less green open spaces than outer areas (Department of Transport Planning and Local Infrastructure 2014). Competing pressures on green open spaces to accommodate future population growth, particularly remaining natural vegetation such as green belts being released for future development.	Existing urban planning and management efforts towards an open green space framework at the city-region scale, and attention to the selection of location, design and management of open green and blue spaces, given its dependence on groundwater systems (Department of Water, 2009b). Competing pressures on green open spaces to accommodate future population growth.

3.2 Data collection

Data were obtained through an online documentary search seeking documents available through national, state and local governments' websites. Documents were purposely selected (Zhang and Wildemuth 2009), and included planning policies, plans and strategies and secondary reports relating to water resource management and land use planning in the three case study areas. A total of 106 documents were chosen for analysis: 38 for the SEQ region, 32 for the Melbourne region and 36 for the Perth region. It should be noted that this analysis is not exhaustive of all available plans and strategies, but was carried out with the aim to

provide insights to differing approaches to green open space planning relating to flood management in these metropolitan regions.

While many urban water management activities, including flood management are planned and carried out by local authorities rather than regional or state authorities (Morison and Brown 2011), and while the cumulative impacts of these local activities can collectively be substantial at a regional scale, documents relating to the local government level, or specific localities were not included. Documents that relate to land use planning and water resource management at a regional scale were chosen for this analysis because the interconnectedness of hydrological functions across landscapes results in a need for water resource management and green open space planning to be done at a catchment, or regional level, which in almost all cases surpasses local authority boundaries (Roy, Wenger et al. 2008, Grose 2009, Carmon and Shamir 2010). Policies and strategies that apply to a regional or greater scale (such as state government, or regionally-based authorities that stipulate policy landscapes for Australian local governments) also play an important role by either constraining water sensitive planning and development (for example, through failing to accommodate local characteristics) (Coombes 2015), or providing an enabling role through provision of guidance and policy support (Kazmierczak and Carter 2010, Daniell, Coombes et al. 2014). Research findings by Daniell et al. (2014) suggest that in order to ensure implementation of actions and systems for integrated water management, support is required from at least two government administrative levels, including one with implementation capacity. Additionally, green open spaces and ecosystem services are crucial aspects in mainstreaming total water cycle management in policy, however the extent to which they remain experimental and limited within practice is unknown. We suggest that an assessment of how well these are being incorporated (or not) into planning and policy documents will give some indication of how effectively integrated urban water management is being pursued at a policy-level.

It is also arguable that evaluations of ecosystem services are best done at a regional level given that ecosystems generally do not correspond with local planning jurisdictional boundaries (Niemelä, Saarela et al. 2010). Because urban development generates impacts at a catchment and regional level, it is important to consider the role of water-related ecosystem services at this same level (Depietri, Renaud et al. 2012) to gain an understanding of the relations between cities and their surrounding interconnected environments and ecosystem services (McGranahan, Marcotullio et al. 2005, Niemelä, Saarela et al. 2010). Appendix 1 (adapted from Serrao-Neumann, Renouf et al. 2017) provides a list of analysed documents across these case study areas.

It should be noted that processes of reform in land use planning and water resource management in the case study areas imply ongoing shifting policy priorities and may not be an accurate reflection of the future policy landscape. Additionally, the documents analysed cover periods of change in governments, and documents prepared by various agencies, and as such are not indicative of particular policy stances of current or previous state governments. Rather, they are a reflection of approaches taken over a longer period of time. We believe this is appropriate, as the urban landscape itself is a display of the impacts of a series of different approaches and plans regarding both land use planning and urban water management implemented over time.

3.4 Data analysis

An in-depth content analysis was performed through a coding system using NVivo software. Coding was guided by a series of topics relating to green open spaces used to carry out text searches: open space, parkland, green space, park, agriculture, wetland, urban forest, riparian, ecosystem services, flood, and planning mechanisms. Although many documents referred to concepts relating to ecosystem services, only document references made specifically to the

term, ‘ecosystem services’ were recorded in the analysis. Similarly, while references made specifically to ‘flood’ were recorded, related matters such as ‘stormwater management’, ‘infiltration’, ‘conveyance’, and ‘drainage’ were not included in NVivo analysis. This analysis is used as an indicator of the extent of recognition and planning actions taken, and useful in highlighting some of the key approaches to green open space planning relating to flood regulation and water-related ecosystem services in the case study areas.

A scoring system adapted from methods used by Geneletti & Zardo (2016) was applied to carry out content analysis of selected documents. This scoring system allowed for a consistent evaluation across the case studies of ‘information base’ and ‘actions and implementation mechanisms’ concerning green open space with respect to: (i) recognising the benefits of green open space in land use planning as a means to provide ecosystem services and flood regulation; and (ii) gaining insights into how science-based reasoning may influence land-use planning actions and / or objectives for implementing green open space (see Table 2). The results of the application of the scoring system were used to compute a percentage of documents assigned different scores for each case study region.

Table 2. Scoring system used to evaluate documents

Score	Information Base	Actions & Implementation Mechanisms
1	Does not acknowledge the benefits of green open spaces specific to flood regulation or ecosystem services	No evidence of action taken
2	Acknowledges the benefits of green open spaces in the context of flood regulation ecosystem services	Mentions actions relating to green open spaces and flood regulation but lacks further definition
3	Acknowledges the benefits of green open space in the context of flood regulation ecosystem services and provides some science-based reasoning for actions/objectives	Mentions specific actions and provides details on their implementation or associated requirements (such as locally-specific details and/or details on budget, responsible bodies etc).

Adapted from: Geneletti & Zardo, 2016.

It is noted that many urban water management actions may have multiple benefits, of which flood management can be just one. Documents may list green open space planning actions that benefit flood management without explicitly acknowledging these benefits. For this reason we have included in the results and discussion sections of this paper some information on broader approaches to green open space planning and water resources management in the case study areas.

4. Results

Findings presented here offer a comparison between the three case studies regarding how green open space planning takes place in each region. Within each of the following sub-sections, findings are reported in two parts and only cover documents that received scoring of 2 and 3. The first part refers to how documents receiving a scoring of 2 acknowledged the benefits for supporting green open space planning for flood regulation and ecosystem

services. The second part identifies how documents receiving a scoring of 3 reported on the use of science-based reasoning to support green open space planning for flood regulation and ecosystem services.

4.1 Information base

With respect to the information base, Figure 2 shows that most relevant documents relating to land-use planning in the case study regions did not acknowledge the benefits of green open space specific to flood regulation or ecosystem services. A limited number of documents acknowledged the links between green open space and flood regulation but lacked further details (6 in SEQ, 8 in Melbourne and 1 in Perth). For example, SEQ documents recommended integrating public green open space with drainage corridors (Department of Energy and Water Supply 2013), restoring connectivity between rivers and floodplains (Department of Infrastructure and Planning 2009), and understanding water cycle needs and flooding vulnerabilities of rural communities (Water by Design 2010). Notably, SEQ's green space strategy makes little mention of the benefits of planning for connected strategically placed green open spaces for managing flood risk for the region. It does acknowledge, however, the role of green open spaces in mitigating the effects of climate change and flooding (Department of Local Government and Planning 2011) along with the state planning policy and a guide to the region's ecosystem services framework (SEQ Catchments 2011, Department of State Development Infrastructure and Planning 2013).

In the Melbourne case study region, documents demonstrated paradigm shifts in the management of overland flow and flood management away from hard engineering solutions such as levee systems, and towards allowing the environment to convey and store floodwater at appropriate times using floodplains, wetlands and other green open spaces such as parks and golf courses (Melbourne Water 2007, Melbourne Water Corporation 2012, Department of Environment and Primary Industries 2013, Department of Environment Land and Water Planning 2015). Melbourne documents also mentioned potential contributions of stormwater harvesting in open space areas to flood risk management (Melbourne Water 2012, Office of Living Victoria 2013), and the contributions of green infrastructure to flood management alongside other amenity and resource management benefits (Living Victoria Ministerial Advisory Council 2012, Melbourne Water 2013).

One Perth based document recognised the benefits of green open space for flood regulation but did not offer science-based reasoning to support the proposal. These recognised benefits of green open space include the establishment of green open spaces that can be used for urban stormwater management, retaining and enhancing waterways, providing scope for urban flood retention and runoff detention features in green open space areas with relatively low sensitivity to flooding, and consideration of permanent water bodies as features in urban areas that contribute to water management functions (Western Australian Planning Commission 2009).

Out of all 106 documents only 6 (1 in Melbourne and 5 in Perth) acknowledged the benefits of green open space in the context of flood regulation and ecosystem services and provided science-based reasoning for actions and objectives. The Melbourne document acknowledged the role of riparian vegetation in minimising flood damage to private and public infrastructure (Department of Environment and Primary Industries 2013). In the case of Perth, there was mention of the benefits of flood control ecosystem services from wetlands (Department of Environment and Conservation 2009), including its flood storage potential (Western Australian Planning Commission 2008). The identification and protection of wetlands and their buffers and hydrological regimes early in development and planning processes is also encouraged (Department of Water 2007, Department of Water 2008, Western Australian Planning Commission 2008). The benefits of waterway restoration in green open spaces in

the context of stormwater management were also recognised (Department of Water 2004), as were the benefits of public open spaces for detention of water during peak flow rates and water levels (Department of Water 2009).

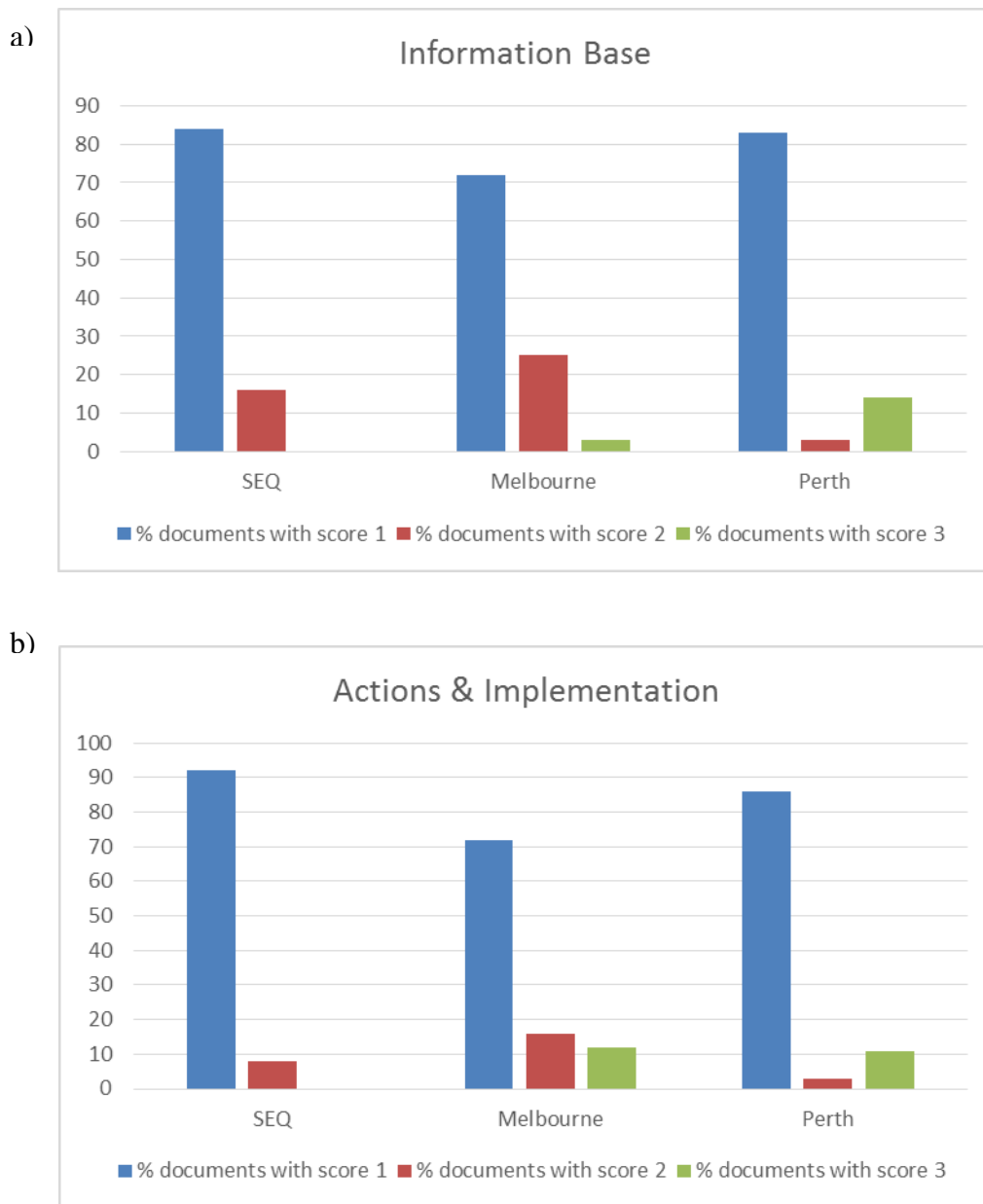


Figure 2. Percentage of analysed documents showing scores for information base (a) and actions and implementation mechanisms (b) relating to green open space planning for each case study region

4.2 Actions and Implementation Mechanisms

Similar to results concerning the information base, the majority of analysed documents did not make references to actions and implementation mechanisms conducive to supporting planning for green open space for flood regulation and ecosystem services (see Figure 2). Few documents across all three regions referred to actions relating to links between green open space and flood regulation but without providing further details regarding implementation (3 in SEQ, 5 in Melbourne and 1 in Perth). Actions mentioned in the SEQ documents included the development of stormwater management plans that include

consideration of flooding, natural flow regime of urban waterways, maximising infiltration and recreational and other green open space values or waterway corridors (Department of Energy and Water Supply 2013); and managing flood risk through retention infrastructure and floodplain connectivity (Department of Infrastructure and Planning 2009). Actions and implementation mechanisms in SEQ also included efforts for greater integration of stormwater management with green open space planning through the inclusion of recreational, open space, landscape and ecological values of waterway corridors, as well as flooding in stormwater management plans (Department of Energy and Water Supply 2013). Opportunities for further acknowledgement and inclusion of WSUD and green infrastructure in infrastructure planning were also highlighted in one document (SEQ Catchments 2011).

In the Melbourne case, documents mentioned the importance of integration of waterway management, floodplain management, public green open space and the planning system (Growth Areas Authority, Melbourne Water 2013); reducing flooding risks through flood mitigation in green open spaces in upper catchments (Office of Living Victoria 2013), stronger planning protection for green open space along major river corridors (Department of Transport Planning and Local Infrastructure 2014), and of enabling enhanced research and understanding of the potential roles of green infrastructure in the region (Living Victoria Ministerial Advisory Council 2012). The Perth based document referred to the establishment of public green open space corridors that follow valley lines and incorporate streams, floodplains and wetlands, storm detention measures, stormwater infiltration and other water quality treatment devices (Western Australian Planning Commission 2009).

Despite acknowledgement of concepts and broad aims, plans and strategies usually provide no accompanying scientific detail or details regarding actions to be implemented. However each case study region has key documents that could be considered important in integrating a number of issues relevant to planning, including green open space planning and flood management. These key regional planning documents (2 in SEQ, 3 in Melbourne and 4 in Perth) did include recognition of the importance of flood management and/or flood-related ecosystem services in green open spaces to varying degrees.

In the case of SEQ, references recommended the protection of urban riparian vegetation and wetlands to maximise water infiltration and reduce the velocity of stormwater as well as retention of pollutants entering waterways (Department of Environment and Heritage Protection 2010); and systematic location of WSUD such as bioretention systems to improve water quality (Water by Design 2010). One notable aspect of SEQ planning is its acknowledgement of ecosystem services in the region through its Ecosystem Services Framework which includes a list of identified relevant ecosystem services, a series of matrices linking ecosystem services alongside their functions, and a series of maps that can be used by planners to identify where ecosystem functions are derived from in the region (SEQ Catchments 2011). This framework acknowledges the contribution of various ecosystem services in the region, including the provision (i.e. retaining and storing) of water for consumptive use, water regulation (SEQ Catchments 2011), and 'buffering against extremes' (Department of Infrastructure and Planning 2009). The development of the Framework identified the protection of flood plains, decreasing sedimentation of waterways and maintaining vegetation through land use planning is crucial in the management of water regulation ecosystem services in SEQ.

In the Melbourne case, a state-based floodplain management strategy described planning mechanisms and strategic reforms required to manage flood risks and meet water management goals (Department of Environment Land and Water Planning 2015). One key planning action identified in this analysis, the Urban Floodway Zone, shows efforts to increase integration of urban planning and water planning and management in order to

benefit green urban spaces and flood management by identifying land affected by flooding in urban areas (Melbourne Water 2007, Melbourne Water 2008, Department of Environment and Primary Industries 2013, Department of Environment Land and Water Planning 2015). Land use and development in land under this zone is restricted to low intensity uses such as recreation and agriculture to allow the conveyance of active flood flows (Melbourne Water 2008). This Urban Floodway Zone is one of several zoning and overlay instruments developed across the Melbourne metropolitan region to assist in preventing constricted floodplains or loss of connectivity between natural flow paths between a river, its floodplain and wetlands.

Perth based documents included aims to integrate stormwater management and open spaces through the establishment of open space networks that can accommodate urban water management measures, including public open space corridors that incorporated streams, floodplains and wetlands, storm detention measures, and stormwater infiltration devices (Western Australian Planning Commission 2009), and the protection of natural drainage lines (Western Australian Planning Commission 2008). A regional water management strategy was tasked with locating multi-use green open space corridors, waterway corridors and wetlands to be protected for water management purposes (Western Australian Planning Commission 2008). It was noted that these open space networks need to be planned interactively with other urban planning processes (Western Australian Planning Commission 2009). Guidance on how the implementation of the regional water strategy and key water policy can be integrated throughout regional and local land use planning processes for greenfield developments and urban renewal was provided through a key policy document (Western Australian Planning Commission 2008).

5. Discussion

Three key insights can be gleaned from the results presented in the previous section. Firstly, there is limited explicit integration of flood management and green open space planning. Secondly, legacies of past planning decisions have generated considerable challenges for planning authorities to use regional green open space planning as an ally for flood management at a regional level. Thirdly, a lack of information can serve to limit the application of flood-related ecosystem services in green open space planning to contribute to flood management.

5.1 Limited integration of flood management and green open space planning

The most notable finding is that despite green open space being touted as important in flood management in much of the literature (De Groot, Alkemade et al. 2010), the analysis of documents reveals that key regional plans and strategies often fail to recognise the links between planning for green open spaces and flood management or related ecosystem services. Furthermore, results show that when these links are recognised it is often of a superficial nature, with little detailed actions, and limited reference to supporting scientific studies.

The data obtained in this analysis shows the inclusion of green open space planning in concert with flood management and/or flood-related ecosystem services in a few documents in every case study, but not consistently across land use planning and water resources management. Several documents state clear policy objectives relating to integration. For example, in recognition of problems stemming from previous tendencies to manage rainwater, stormwater, waterways, and open space components in isolation, integrating urban planning and water cycle management at a city/regional scale is a key strategic objective in some Melbourne documents (Office of Living Victoria 2012, Office of Living Victoria

2014). Looking at connections between green open spaces, waterways and stormwater has accompanied the emergence of goals to increase the volume of stormwater retained in the landscape (particularly in upper catchment areas) and flowing through green spaces before entering drainage/waterways (Office of Living Victoria 2013). Achieving this may not only benefit flood management, but also water demand management, ecological health of waterways, and urban amenity (Walsh, Fletcher et al. 2012, Office of Living Victoria 2013).

In Perth, guidance on how the implementation of the regional water strategy as well as key water policy can be integrated with land use planning for greenfield developments and urban renewal is provided through a key urban water management document that identifies how water resources can be considered, investigated and addressed at each planning stage. This guidance relates to regional as well as local scale planning processes (Western Australian Planning Commission 2008).

Although there are varying levels of integration, and it is clear that there is considerable effort to better integrate water management with urban planning generally in each case study region, specific efforts and policy objectives to increase integration in relation to specific issues of flood-related ecosystem services and green open spaces are less common. McCallum & Boulot (2015) claim that the concept of urban areas as water catchments remains undeveloped across the case study regions. They argue that although there are efforts to include integrated water catchment management into land use planning in those regions, results are piecemeal. Similarly, Head (2014) suggests that strategic policy frameworks in SEQ have struggled to integrate plans and related information relating to drought, flood, and catchment ecology. The results presented here in this policy analysis support the conclusions by these authors insofar as their recognition of the flood-regulating ecosystem services green open spaces can contribute to urban catchments.

The case studies differ in their level of acknowledgement of, and efforts to maintain, water-related ecosystem services. Planning actions and implementation in response to water challenges also differ across the case study regions. Although the analysis demonstrates considerations of water management in green open space planning and design in the case study areas, it is difficult to accurately assess the priority given to water management and water-related ecosystem services in relation with other numerous competing objectives. Similarly, Head (2014) encountered difficulties assessing processes of developing, evaluating and integrating alternative flood management options with broader urban management objectives in SEQ due to limited transparency in policy deliberations. A relatively low priority given to flood-related ecosystem services in green open space planning may confirm Berke et al.'s (2003) suggestion that new urban design codes often fail to take full advantage of opportunities to protect hydrologically sensitive areas due to competing urban design objectives being prioritised above attention given to water-related ecosystem services in urban planning. Taking the Perth metropolitan region as an example, Grose (2009) has documented conflicting values attributed to public green open space planning; in particular, reporting that land for the ecological and amenity values of retention basins often compete spatially with recreational values, and arguing that ecological imperatives of green open space planning need to be prioritised.

5.2 Legacies of past planning decisions compromising green open space planning

The current fabric of urban areas is largely the result of past land development and planning decisions in which there was little regard to flood risk (Lennon, Scott et al. 2014) or flood-related ecosystem services of green open spaces. A traditional focus on 'hard' engineering solutions to flood management such as levees, flood barriers and underground piping of historical drainage channels, along with the location of human settlements and infrastructure along floodplains in many areas, can have long lasting impacts on the landscape (Brown,

Keath et al. 2009, Lennon, Scott et al. 2014). Analysed plans and strategies, as well as literature more broadly (Brown, Keath et al. 2009), have documented paradigm shifts and growing recognition of newer approaches to managing flood risk that focus more on restoring natural water storage capacity in the landscape and natural surface water flow paths. However, flood mitigation using newer approaches will take time to have significant impacts at a landscape scale in these areas, as retrofitting can only occur slowly (Ashley, Nowell et al. 2011).

Some shared challenges can be seen across all three case study regions relating to legacies of past infrastructure and planning approaches (such as development of floodplain areas) that have increased current flood vulnerabilities and influenced current regulatory and institutional arrangements (McCallum and Boulot 2015). For example, both SEQ and Melbourne metropolitan regions have experienced increased flood risks as a result of previous development on floodplains (Low Choy, Baum et al. 2010, Head 2014) as well as development that has blocked natural drainage lines and flow paths (Office of Living Victoria 2013). Head (2014) argues that even following a major flood in SEQ in 2011, there has been little attention paid to reserving low-lying areas for more appropriate uses than residential and industrial uses as has been allowed in previous decades.

As well as legacies relating to infrastructure and development, McCallum and Boulot (2015) argue that current regulatory and institutional arrangements in each case study area have also been influenced by legacies of past water management as well as recent extreme events and changes in rainfall and runoff. As ageing stormwater networks come to need renewal or replacement, more opportunities to introduce source control measures and innovative urban water and flood management solutions may emerge (Barton et al. 2007 in Office of Living Victoria 2014, Coombes 2015) that are integrated with green open space networks.

5.3 Lack of information supporting flood-related ecosystem services in green open space planning

Findings also indicated a great variation in the level of recognition of flood related ecosystem services and their inclusion in planning actions in the case study regions. In addition to the acknowledgement of the role of ecosystem services, information about the ways in which different ecosystem services interact, and the requirements for their maintenance is crucial for good decision making in landscape management and planning (World Resources Institute 2005). Although there is increasing understanding of the importance of green open spaces in urban regions, there is less understanding of the relationship between approaches to green open space planning and mechanisms for the generation of urban ecosystem services (Andersson, Barthel et al. 2014).

Melbourne actions and implementation mechanisms include research into the costs and benefits of green infrastructure. Although Melbourne based documents do not explicitly acknowledge flood-related ecosystem services of green open spaces, this action may help generate information to assist planners to maintain water-related ecosystem services in green open spaces, and anticipate related consequences of design and land use in green open spaces. This is important, as ecosystem services of flood regulation are affected by complex interactions in the landscape (such as hydrology and land use and environmental change) (Haase and Nuissl 2007), and more information and understanding is needed to support planning decisions affecting ecosystem services in urban regions (Niemelä, Saarela et al. 2010, Guswa, Brauman et al. 2014).

Additionally, the SEQ focused Ecosystem Services Framework involved much effort to compile information and provide tools to enable the implementation of planning actions based on the concept of ecosystem services (Maynard, James et al. 2010). This is important, as the scientific discourses for green infrastructure and ecosystem services concepts are often

lacking application-oriented frameworks that are suitable to mainstream these concepts in planning practice in a holistic way (Niemela, Saarela et al. 2010, Hansen and Pauleit 2014), and there have been calls for greater emphasis on values of green assets and green infrastructure in land use planning (Schäffler and Swilling 2013). However, for regions with complex hydrologic system dynamics involving surface and underground water such as the Perth region, satisfying these needs for information and understanding of water systems may be particularly challenging (Grose 2009).

This search for more information is an overall theme in efforts to mainstream water sensitive approaches to urban planning. Uncertainties regarding the operational performance of stormwater harvesting, green infrastructure and WSUD measures (Fletcher, Shuster et al. 2015) has been identified as hindering their wider uptake (Burns and Mitchell 2008, and Brown in Sharma, Cook et al. 2012). Similarly, Coombes et al. (2012) discovered a limited availability and use of spatial and temporal data at a metropolitan regional scale and argued that this has acted as a barrier to the development of innovative strategies for many water authorities in Melbourne. Godden & Kung (2011) recommend a review of existing flood mitigation measures in Australia to ensure they are flexible in response to changing information needs and guidelines stemming from future climate changes and uncertainties .

6. Conclusions and Recommendations

This paper reported on the extent to which current land use planning and water resource management support green open space planning for ecosystem services and functions such as flood regulation in three Australian capital city regions: SEQ, Melbourne and Perth. Some paradigm shifts are occurring across the regions towards a holistic approach to urban water management due to growing pressures relating to population growth, climate change, increasing risks of flood and drought, water security, and environmental quality decline. For example, in SEQ there have been efforts to mainstream concepts of ecosystem services in strategic regional scale land use planning. In Melbourne, efforts seek to increase integration in water management and urban planning, address flood and drought issues using stormwater harvesting, and zoning measures to enhance floodplain connectivity. In Perth, green open space planning and growth management have been historically rooted in water resource management, and there are operational policies for the design and assessment of regional, district and local structure plans that encourage public green open space along natural drainage corridors and waterways.

However, findings also indicate piecemeal planning approaches, which have been cited as a common challenge in achieving goals in integrated urban water resource management. Additionally, despite green open spaces being touted as important in flood management and water-related ecosystem services, the analysis revealed that concepts of careful planning of green open spaces for flood management and the maintenance of flood-related ecosystem services are often not present in plans and strategies, and when they are, it is often of a superficial nature (lacking implementation details, or lacking science-based reasoning).

While it is inherently difficult to assess the relative perceived importance and prioritisation of issues of integrating green open space planning and flood management and/or flood related ecosystem services, the superficial nature of most references to the topics indicate that the priority is not high. Furthermore, competing interests in regional land use planning may be limiting opportunities for prioritising maintenance of flood-related ecosystem services in green open space planning. Compounding these challenges is the legacy of both past land use planning and water resource management decisions that make it difficult to retrofit existing urbanised areas with green open spaces, or restore hydrological and ecological connectivity conducive to supporting ecosystem services and functions performed by such spaces. Lastly,

the operationalization of the concept of ecosystem services in land use planning and water resource management is not straightforward and is still being developed, resulting in a lack of information to support implementation.

To overcome these shortfalls, this research supports numerous calls for improved integration between land use planning (including green open space planning) and water resource management. In particular, it is only through improved integration that the different functions performed by water in urban areas can be better accounted for to support the restoration, or maintenance, of hydrological and ecological connectivity which is critical to reduce urbanisation impacts on water related ecosystem services and functions such as flood regulation. To this end, this study highlights that the benefits of green open spaces in assisting hydrological and ecological connectivity at the city-region scale need to be fully acknowledged and pursued by land use planning processes. This should be a primary consideration in decisions regarding the placement of new settlements, extension of existing ones, and water-related infrastructure, as also noted by other authors.

Additionally, while planning for multi-functional green open spaces is a relatively new concept yet to be tested in its full potential, this consideration should permeate land use planning and design processes; especially as an attempt to revert some of the negative effects borne from past land use planning and water resource management decisions. This multi-functionality needs to be integrated with water resource management along with other planning considerations, such as grey infrastructure planning and community facilities, to protect hydrologically sensitive areas and water-related ecosystem services.

The development of water sensitive green open space networks and concepts of green infrastructure and ecosystem services as an ally to flood management requires application-oriented frameworks that are suitable to be mainstreamed into planning practice in a holistic way. More attention is therefore needed towards ways in which the values of green assets and green infrastructure might be incorporated into land use planning. However, simplistic panaceas or blueprints will be insufficient to address the complex issues associated with water-related ecosystems services, green open space planning and flood management. This warrants ongoing research to expand understanding of the consequences of different land use patterns for water and flood related ecosystem services, as well as continued assessments of the efficiency of implemented WSUDs and multi-functional green open spaces.

Finally, urban areas impact and are dependent on water resources beyond the boundaries of their built up areas. Hence, to advance water resource management from a whole-of-water cycle perspective, including through improved integration between land use and water resource planning, it is imperative to consider spatial scales beyond the boundaries of local authorities which criss-cross the regional landscape. The impact of decisions (and associated infrastructure and urban development) on regional waterways carried out at the local scale needs to be thoroughly assessed to avoid cascading effects throughout the whole catchment. This regional/ landscape scale oriented policy requires a significant level of collaboration and coordination between the urban planning and water management sectors which needs to be supported by overarching state level institutional arrangements and legislation, and informed by the best available science. Without these levels of collaboration and coordination we will continue to deliver a piecemeal approach when managing urban water.

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Appendix 1. Analysed documents by case study region (adapted from Serrao-Neumann et al., 2017)

South East Queensland region	Melbourne Metropolitan region	Perth Metropolitan region
<p>Healthy Waters, Department of Environment and Resource Management 2010 <i>Urban Stormwater Planning Guidelines</i>, http://www.onsiteisite.com/SiteFiles/whiteheadenvironmentalinfocomau/DERM_Urban_Stormwater_Quality_Planning_Guidelines_2010.pdf</p>	<p>Department of Sustainability and Environment 2011 <i>A Governance Guide to VIC Water Industry</i>, http://www.depi.vic.gov.au/_data/assets/pdf_file/0010/181657/Governance-Guide-Print-update2a.pdf</p>	<p>Department of Health 2010 <i>Code of Practice for the Reuse of Greywater in Western Australia 2010</i>, http://www.public.health.wa.gov.au/cproot/1340/2/COP%20Greywater%20Reuse%202010_v2_130103.pdf</p>
<p>Department of Environment and Heritage Protection 2013 <i>Healthy Water Management Plans Guideline</i>, https://www.ehp.qld.gov.au/water/policy/pdf/healthy-water-mp-guideline.pdf</p>	<p>EPA VIC 2009 <i>Better Bays and Waterways</i>, http://www.epa.vic.gov.au/our-work/programs/~media/Files/water/coasts/docs/BetterBaysWaterways-WQIP-FINAL.pdf</p>	<p>Department of Water 2004 <i>Stormwater Management Manual for Western Australia</i>, https://www.water.wa.gov.au/_data/assets/pdf_file/0020/4772/44217.pdf</p>
<p>Department of Energy and Water Supply 2010 <i>Planning Guidelines for Water Supply and Sewerage</i>, https://www.dews.qld.gov.au/_data/assets/pdf_file/0016/80053/water-sewerage-planning-guidelines.pdf</p>	<p>Growth Areas Authority <i>Integrated Water Management</i>, PSP Notes, http://www.mpa.vic.gov.au/wp-content/Assets/Files/PSP_Guidelines_Notes_Integrated_Water_Management%5B1%5D.pdf</p>	<p>Department of Water 2008 <i>Interim: Developing a Local Water Management Strategy</i>, https://www.water.wa.gov.au/_data/assets/pdf_file/0015/4218/83705.pdf</p>
<p>Department of Energy and Water Supply 2013 <i>Qld Urban Drainage Manual</i>, https://www.dews.qld.gov.au/_data/assets/pdf_file/0008/78128/qudm2013-provisional.pdf</p>	<p>Melbourne Water 2007 <i>Principles for Provision of Waterway and Drainage Services for Urban Growth</i>, http://www.melbournwater.com.au/Planning-and-building/Forms-guidelines-and-standard-drawings/Documents/Principles-for-provision-of-waterway-and-drainage-services-for-urban-growth.pdf</p>	<p>Department of Water 2009 <i>Decision Process for Stormwater Management in WA</i>, http://www.tritonsws.com/downloads/108-87810.pdf</p>
<p><i>Healthy Waterways Strategic Plan 2012-22</i>, Healthy Waterways</p>	<p>Melbourne Water 2008 <i>Guidelines for Development in Flood-prone Areas</i>, http://www.melbournwater.com.au/planning-and-building/forms-guidelines-and-standard-drawings/documents/flood-prone-area-development-guidelines.pdf</p>	<p>Department of Water 2009 <i>Jandakot Drainage and Water Management Plan Peel main drain catchment</i>, http://www.water.wa.gov.au/_data/assets/pdf_file/0018/1746/91068.pdf</p>
<p>Queensland Urban Utilities <i>Recycled Water Policy</i>, https://www.urbanutilities.com.au/~media/quu/pdfs/about%20us/policies/pol139.ashx</p>	<p>Melbourne Water 2012 <i>Waterways Operating Charter 2013-2018</i>, Melbourne Water Corporation</p>	<p>Department of Water 2012 <i>Water monitoring guidelines for better urban water management strategies and plans</i>, http://www.water.wa.gov.au/_data/assets/pdf_file/0012/3630/104023.pdf</p>
<p>Queensland Urban Utilities <i>Water Netserv Plan Part A</i>,</p>	<p>Melbourne Water 2010 <i>Planning for Sea Level Rise</i>, http://www.melbournwater.com.au/Planning-and-</p>	<p>Department of Water 2013 <i>Better Urban Water Management Guidance Notes 1-3</i>,</p>

http://www.urbanutilities.com.au/~media/quu/pdfs/about%20us/publications/water%20network%20plan%20part%20a_cma_250112_newcovermoleed.dashx	building/Forms-guidelines-and-standard-drawings/Documents/Planning-for-sea-level-rise-guidelines.pdf	http://www.water.wa.gov.au/planning-for-the-future/water-and-land-use-planning/better-urban-water-management
Queensland Water Supply Regulator 2010 <i>Planning Guidelines for Water Supply And Sewerage</i> , https://www.dews.qld.gov.au/_data/assets/pdf_file/0016/80053/water-sewerage-planning-guidelines.pdf	<i>DELWP 2015 Vic Floodplain Mgt Strategy revised draft</i>	Department of Water 2013 <i>Water resource considerations when controlling groundwater levels in urban development</i> , http://www.water.wa.gov.au/_data/assets/pdf_file/0012/1722/104909.pdf
SEQ Catchments 2011 <i>Guide to Ecosystem Services Framework</i>	Department of Environment and Primary Industries 2013 <i>Waterway management strategy</i> , http://www.depi.vic.gov.au/water/rivers-estuaries-and-wetlands/strategy-and-planning	Department of Planning 2010 <i>Directions 2031</i> , http://www.planning.wa.gov.au/publications/826.asp
SEQWater 2012 <i>Development Guidelines</i> , http://www.seqwater.com.au/sites/default/files/PDF%20Documents/Publications/SEQ%20Land%20and%20Water%20Development%20Guidelines%20June%202012.pdf	Department of Sustainability and Environment 2011 <i>Improving our waterways, Draft Victorian Waterway Management Strategy</i> , Victorian Government	Department of Planning 2010 <i>Outer Metro Perth and Peel Sub-regional Strategy</i> , http://www.planning.wa.gov.au/publications/990.asp
Water by Design 2010 <i>Deemed to Comply Solutions SEQ V1.0</i> , http://waterbydesign.com.au/wp-content/uploads/2010/06/Deemed-to-Comply-Solutions-SEQ-V1.0.pdf	Ministerial Advisory Council 2011 <i>Living Melbourne, Living Victoria Roadmap</i> , http://www.water.vic.gov.au/resources/news_items/news_items_folder/?a=107658	Department of Planning 2011 <i>Central Metro Perth Sub-regional Strategy</i> , http://www.planning.wa.gov.au/publications/762.asp
Water by Design 2010 <i>TWCM Planning Guideline for SEQ</i> , https://www.ehp.qld.gov.au/water/policy/pdf/twcmp-guideline.pdf	Ministerial Advisory Council 2012 <i>Living Victoria Implementation Plan</i> , Victorian Government	Department of Planning 2013 <i>Capital City Planning Framework</i> , http://www.planning.wa.gov.au/publications/2632.asp
Department of Environment and Resource Management 2009 <i>SEQ Natural Resource Management Plan 2009-31</i> , SEQ Catchments	Department of Transport, Planning and Local Infrastructure 2013 <i>Open Space Strategies - PN70</i> , http://www.dtpli.vic.gov.au/_data/assets/pdf_file/0011/229547/70-Open-space-strategies-PN70.pdf	Western Australian Planning Commission 2008 <i>Better Urban Water Management</i> , http://www.planning.wa.gov.au/dop_pub_pdf/Better_Urban_Water_Management.pdf
Department of Energy and Water Supply 2013 <i>Queensland Water Sector: a 30 year Strategy, Discussion Paper</i> , https://www.dews.qld.gov.au/_data/assets/pdf_file/0013/31144/30yr-water-strategy-discussion-paper.pdf	Department of Transport, Planning and Local Infrastructure 2013 <i>Plan Melbourne 2050</i> , Victorian Government	Western Australian Planning Commission 2008 <i>Planning Bulletin 92 Urban Water Management</i> , http://www.planning.wa.gov.au/dop_pub_pdf/Plan_bulletin_92.pdf
Department of Energy and Water Supply 2014 <i>WaterQ 30 Year Strategy</i> ,	Department of Transport, Planning and Local Infrastructure 2013 <i>Plan Melbourne Directions</i>	Western Australian Planning Commission 2009 <i>Liveable Neighbourhoods</i> ,

<p>https://www.dews.qld.gov.au/_data/assets/pdf_file/0007/176344/waterq-strategy.pdf</p>	<p><i>Initiatives and Actions</i>, http://www.planmelbourne.vic.gov.au/_data/asset/pdf_file/0016/131443/Plan-Melbourne-Directions-Initiatives-and-Actions.pdf</p>	<p>http://www.planning.wa.gov.au/dop_pub_pdf/LN_T_ext_update_02.pdf</p>
<p>Queensland Environmental Protection (Water) Policy 2009, https://www.legislation.qld.gov.au/LEGISLTN/CURRENT/E/EnvProWateP09.pdf</p>	<p>Melbourne Water 2007 <i>Flood Management and Drainage Strategy</i>, http://www.melbournewater.com.au/aboutus/reportsandpublications/key-strategies/Documents/Flood_Management_and_Drainage_Strategy_complete.pdf</p>	<p>Department of Environment and Conservation 2012 <i>Adapting to our changing climate</i>, http://www.der.wa.gov.au/images/documents/yourenvironment/climate-change/adapting-to-our-changing-climate-october-2012.pdf</p>
<p>Queensland Government 2011 <i>Greenspace Strategy 2011-20</i>, http://qorf.org.au/wp-content/uploads/2014/04/Queensland_Greenspace_Strategy2011.pdf</p>	<p>Melbourne Water 2007 <i>Port Phillip and Westernport Regional River Health strategy</i>, http://melbournewater.com.au/aboutus/reportsandpublications/key-strategies/Documents/Port%20Phillip%20and%20Westernport%20Regional%20River%20Health%20Strategy%20-%20Full%20strategy.pdf</p>	<p>Department of Water 2009 <i>Draft Perth-Peel Regional Water Plan 2010-2030</i>, draft for public comment, https://www.water.wa.gov.au/_data/assets/pdf_file/0015/1806/90639.pdf</p>
<p>Queensland Government 2013 <i>The Queensland Plan</i>, http://queenslandplan.qld.gov.au/</p>	<p>Melbourne Water 2012 <i>Draft Healthy Waterways Strategy</i>, Melbourne Water Corporation</p>	<p>Department of Water 2009 <i>Strategic directions to 2030, Perth-Peel regional water plan discussion paper</i>, https://www.water.wa.gov.au/_data/assets/pdf_file/0010/4996/88686.pdf</p>
<p>Queensland Water Commission 2010 <i>SEQ Water Strategy</i>, https://www.dews.qld.gov.au/_data/assets/pdf_file/0019/32734/seqws.pdf</p>	<p>Melbourne Water 2012 <i>Draft Stormwater Strategy</i>, http://melbournewater.com.au/aboutus/reportsandpublications/key-strategies/Documents/2013-14%20to%202017-18%20Draft%20Stormwater%20Strategy.pdf</p>	<p>Department of Planning 2013 <i>Review of the Planning and Development Act 2005</i>, http://www.planning.wa.gov.au/dop_pub_pdf/review_planning_act.pdf</p>
<p><i>SEQ Healthy Waterways Strategy 2007-2012</i>, Healthy Waterways</p>	<p>Melbourne Water <i>Setting our Strategic Direction</i>, http://www.melbournewater.com.au/aboutus/who-weare/ourvision/Documents/Strategic_Direction.pdf</p>	<p>Government of Western Australia 2009 <i>Gnangara sustainability strategy, Analysis of Public Submissions</i>, http://www.svpa.com.au/index_files/GSSAnalysisOfPublicSubmissions.pdf</p>
<p><i>SEQ Water Strategic Plan 2011 to 2016</i>, SEQ Water</p>	<p>Office of Living Victoria 2012 <i>Water Cycle Management Business Strategy</i>, Victorian Government</p>	<p>Government of Western Australia 2009 <i>Gnangara Sustainability Strategy</i>, Draft for public comment, https://www.water.wa.gov.au/_data/assets/pdf_file/0003/4926/82087.pdf</p>
<p>Department of Environment and Resource Management <i>Understanding Water Resource</i></p>	<p>Office of Living Victoria 2013 <i>Melbourne's Water Future</i>, consultation draft, Victorian Government</p>	<p>Regional Development Australia 2013 <i>Perth Regional Plan 2013-16</i>, Regional Development</p>

<p><i>Planning, Queensland Government</i></p> <p>Department of Energy and Water Supply 2013 <i>Bulk water supply code</i>, https://www.dews.qld.gov.au/_data/assets/pdf_file/0013/32305/bulk-water-supply-code.pdf</p>	<p>Office of Living Victoria 2014 <i>Metropolitan Whole-of-Water-Cycle Strategic Framework (Metro Framework Discussion Paper)</i>, Victorian Government</p>	<p>Australia</p> <p>Water Corporation 2009 <i>Water Forever Toward Climate Resilience</i>, https://www.watercorporation.com.au/~media/files/about-us/planning-for-the-future/water-forever-50-year-plan.pdf</p>
<p>Department of Environment and Water Supply 2013 <i>Water and Sewerage Services Code for Small Customers in SEQ</i>, https://www.dews.qld.gov.au/_data/assets/pdf_file/0014/32306/water-sewerage-services-code.pdf</p>	<p>South East Water 2013 2013-18 Draft Water Plan, South East Water, http://southeastwater.com.au/SiteCollectionDocuments/AboutUs/2013_Draft_Water_Plan.pdf</p>	<p>Water Corporation 2011 <i>Water Forever Whatever the Weather</i>, http://www.watercorporation.com.au/~media/files/about-us/planning-for-the-future/perth-10-year-water-supply-strategy.pdf</p>
<p>Queensland Government 2014 <i>Planning and Development Bill</i>, https://www.legislation.qld.gov.au/Bills/54PDF/2014/PlanningDevB14E.pdf</p>	<p>BMT WBM 2013 <i>integrated water management opportunities for Melbourne's growth areas</i></p>	<p>Department of Environment and Conservation 2009 <i>Gnangara Sustainability Strategy (GSS) Biodiversity Values and Threatening Processes Groundwater System</i>, Department of Environment and Conservation</p>
<p><i>Queensland Water Act 2000</i>, https://www.legislation.qld.gov.au/legisltm/current/w/watera00.pdf</p>	<p>Melbourne Water 2013 <i>An Integrated Water Future for Melbourne's North</i>, http://www.melbournewater.com.au/whatwedo/Liability-and-environment/Integrated_Water_Management/Documents/Northern_growth_area_IWCMP.pdf</p>	<p>Department of Water 2009 <i>Gnangara Groundwater Allocation Plan: Evaluation statement 2009-2011</i>, https://www.water.wa.gov.au/_data/assets/pdf_file/0003/1758/106120.pdf</p>
<p><i>Queensland Water Efficiency Labelling Standards Act 2005</i>, https://www.legislation.qld.gov.au/LEGISLTN/CURRENT/W/WatrEfyLSA05.pdf</p>	<p>Melbourne Water Corporation and Victorian Government <i>Melbourne Water 101</i>, http://www.melbournewater.com.au/aboutus/who-weare/ourvision/Documents/Melbourne-Water-101-2015.pdf</p>	<p>Department of Water 2009 <i>Perth Regional Aquifer Modelling System (PRAMS) scenario modelling for the Gnangara Sustainability Strategy</i>, http://www.water.wa.gov.au/_data/assets/pdf_file/0012/4323/90782.pdf</p>
<p><i>Queensland Water Regulation 2002</i>, https://www.legislation.qld.gov.au/LEGISLTN/CURRENT/W/WaterR02.pdf</p>	<p>Melbourne Water 2011 <i>Understanding the Western Port Environment</i>, http://www.melbournewater.com.au/aboutus/reportsandpublications/Research-and-studies/Documents/Understanding_the_Western_Port_Environment.pdf</p>	<p>Department of Water 2009 <i>Land and Water Planning Perth-Peel regional water plan background paper</i>, http://www.water.wa.gov.au/_data/assets/pdf_file/0003/5169/89513.pdf</p>
<p>Department of Infrastructure and Planning 2008 WSUD Design objectives for urban stormwater management, http://www.dilgp.qld.gov.au/resources/guideline/water-sensitive-urban-design-draft-seq.pdf</p>	<p><i>Catchment and Land Protection Act 1994</i>, http://www.ppwcma.vic.gov.au/resources/docs/Catchment%20and%20Land%20Protection%20Act%201994%20-%20Version%20040.pdf</p>	<p>Department of Water 2009 <i>Water efficiency, recycling and alternative supplies</i>, Perth-Peel regional water plan background, https://www.water.wa.gov.au/_data/assets/pdf_file/0007/4399/88707.pdf</p>

Department of Infrastructure and Planning 2009 <i>SEQ Regional Plan 2009-2031</i> , http://www.dilgp.qld.gov.au/resources/plan/seq/regional-plan-2009/seq-regional-plan-2009.pdf	Department of Transport, Planning and Local Infrastructure 2014 <i>Plan Melbourne</i> , http://www.planmelbourne.vic.gov.au/_data/assets/pdf_file/0016/131362/Plan-Melbourne-May-2014.pdf	Department of Water 2009 <i>Toward a Water Sensitive City, The urban drainage initiative – phase 2</i> , http://www.water.wa.gov.au/_data/assets/pdf_file/0009/5022/85823.pdf
Department of State Development, Infrastructure and Planning, <i>State Planning Policy</i> , July 2014, http://www.dilgp.qld.gov.au/resources/policy/state-planning/state-planning-policy-jul-2014.pdf	<i>Water Act 1989</i> , http://www.austlii.edu.au/au/legis/vic/consol_act/wa198983/	Department of Water 2010 <i>Predicting the Future Demand For Water Resources in Western Australia</i> , http://www.water.wa.gov.au/_data/assets/pdf_file/0011/2612/90953.pdf
Department of State Development, Infrastructure and Planning, State Planning Policy 2013, <i>Coastal protection state planning regulatory provision</i> , http://www.dilgp.qld.gov.au/resources/factsheet/planning/coastal-protection-sprp.pdf	Water Supply-Demand Strategy for Melbourne 2006-2055, http://southeastwater.com.au/SiteCollectionDocuments/AboutUs/Water_Supply-Demand_Strategy.pdf	Department of Planning 2013 <i>Planning makes it happen: phase 2</i> , Planning reform discussion paper, http://www.planning.wa.gov.au/dop_pub_pdf/planingreform_discussionpaper.pdf
<i>Southern SEQ Distributor Retailer-Authority Participation Agreement</i> 2011, http://www.logan.qld.gov.au/_data/assets/pdf_file/0019/87400/Participation-Agreement-consolidated-version-incorporating-Amendment-no-2.pdf		GHD 2008 <i>Report for Potential Use of Stormwater in the Perth Region</i> , https://www.water.wa.gov.au/_data/assets/pdf_file/0004/1786/84394.pdf
<i>State Planning Policy 2014</i> , http://www.dilgp.qld.gov.au/resources/policy/state-planning/state-planning-policy-jul-2014.pdf		Western Australian Planning Commission 2014 <i>Planning makes it happen, a blueprint for planning reform</i> , http://www.planning.wa.gov.au/dop_pub_pdf/Blueprint_document_interactive.pdf
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<i>Water Resource (Moreton) Plan 2007</i> , https://www.legislation.qld.gov.au/LEGISLTN/CURRENT/W/WatResMorP07.pdf		
Queensland Water Commission 2012 <i>SEQ Water Strategy Annual Report</i> , Queensland Water		

Commission

Classification of documents:

statutory policy

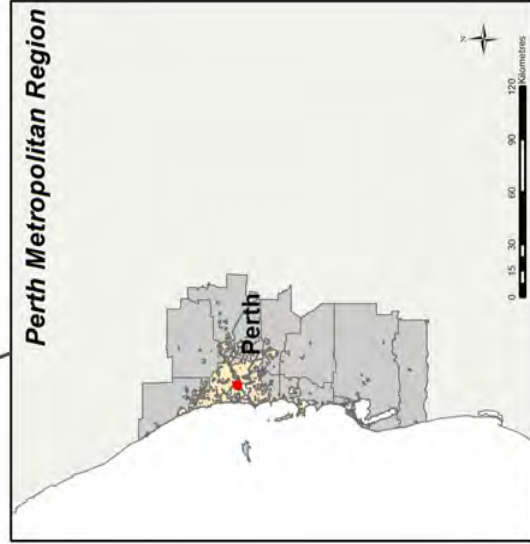
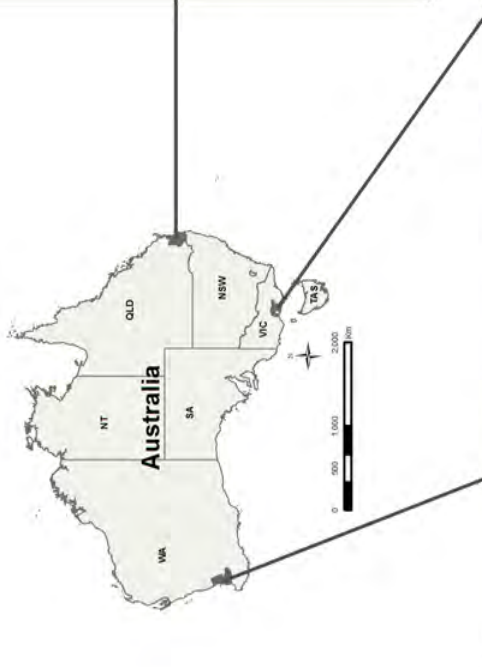
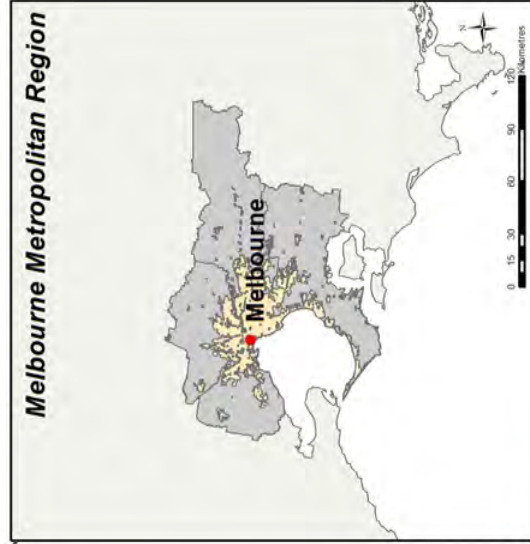
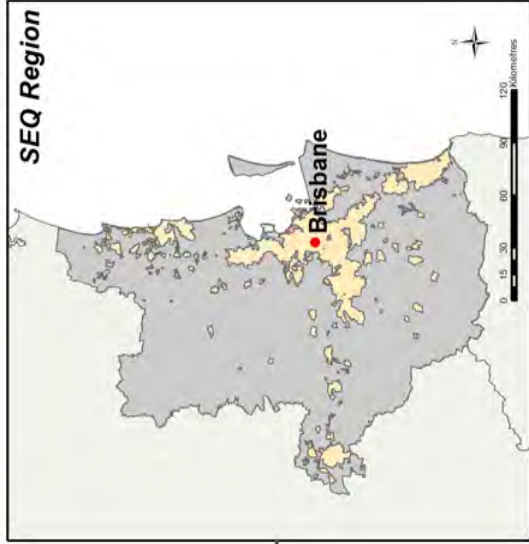
non-statutory guide

non-statutory plan/strategy

corporate report

background document

Note: classification of documents reflects document status at the time of its publication. This is subject to change in some cases.



Urban footprint Regional boundary

Water in the city: Green open spaces, land use planning and flood management – an Australian case study

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