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Waterways as social assets: Filling the gap in waterway design guidelines

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ABSTRACT: *The link between exposure to nature and improved human health outcomes is well accepted by both health professionals and the community at large. Urban waterways present an opportunity to provide this exposure to nature within an urban setting, while serving multiple benefits to the community.*

Even though we understand the 'why', those involved with urban waterway design and rehabilitation are still lacking a definitive 'how' to achieve these health outcomes in practice. Engineers are bound by guidelines addressing the design or rehabilitation of urban waterways for fish passage, public safety, erosion protection, flood mitigation, water quality improvement and flood safety. By comparison, very little guidance currently exists to inform social outcomes.

The paper 'More than flooding and nutrients: a study of the mental health benefits of waterways' (Fletcher, 2016), started the journey by presenting a range of qualitative design elements. This presentation advances a quantitative guideline, to be used in conjunction with other standards, to achieve the best overall outcomes for the community and environment.

Desirable waterway outcomes are determined based on community surveys within the greater Brisbane region and field investigations of a range of sites within South East Queensland. Waterway features that promote interaction and social benefits will be presented as a quantitative guide to lead waterway designers to better outcomes.

KEYWORDS: social, mental health, CPTED, nature, waterway, design, accessible.

1 Introduction

The link between exposure to nature and improved general wellbeing is generally understood. This has been presented in literature for decades including the quintessential book *Biophilia*[1] in 1986 and Maller et al[2] in 2006.

Documents such as the Living Waterways Framework[3] attempt to promote design for social outcomes proposing an alternate scoring system whereby water quality impacts were scored in addition to broader factors including educational value and community cost. More recently, the UN Sustainable Development Goals [4] incorporate goals and corresponding targets covering a range of social outcomes including provision of inclusive and accessible green and public spaces.

Despite extensive literature and research into the topic, there remains little evidence in the form of quantitative design guidance to inform urban design which achieves these outcomes.

The majority of waterway design guidelines do not include standards relating to social outcomes. Where included, they are typically qualitative and do not provide sufficient guidance to allow for criteria-based assessment for approving authorities. This places a reliance on local authorities, the individual designers or asset owners to seek these outcomes as 'added value' outside of the base scope and therefore possibly reduces the frequency of positive social outcomes.

The purpose of this paper is 1) to identify gaps between our current design guidelines, focussing on the South East Queensland region, and broader strategy documents regarding the facilitation of human interaction with green space specific to urban waterway

design and 2) to propose quantitative design standards which may be applied to fill these gaps.

2 The relevance of urban waterway design to social strategy goals

Urban waterway design, while not often directly referenced, fits within several social wellbeing strategies, both internationally and within Australia. They may be incorporated into goals of exposing the community to more 'green' or 'blue' space, providing recreational opportunities within nature, or increasing the open space or vegetation coverage of a city.

The following sections highlight, at an international, national and local Brisbane level, key linkages between waterway design and social strategy documents.

2.1 Sustainable Development Goals (SDGs)

In 2015, 193 United Nations Member States adopted the 2030 Agenda for Sustainable Development. At the core of this agenda was the 17 Sustainable Development Goals (SDGs) [4], promoting a development approach which incorporates 169 targets to address social, economic and environmental impacts.

Goal "SDG 11", aims to 'make cities and human settlements inclusive, safe, resilient and sustainable'. Specifically, Target 11.7 aims to achieve '*universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities'*. According to the SDG indicators, this is measured as follows:

- *'Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities'*.

In Australia, the Infrastructure Sustainability Council of Australia (ISCA) rating Scheme"[5] (IS) is the only comprehensive rating system for evaluating sustainability across the planning, design, construction and operational phases of infrastructure programs, projects, networks and assets. IS v2.0 evaluates the sustainability performance of infrastructure development using metrics which have all been linked to any relevant SDG's.

Encouraging the design of safe and inclusive waterways may assist to achieve better ISCA ratings and work towards achievement of the SDGs.

2.2 Brisbane City Council strategy documents

At a local level, review of urban strategy documents in Brisbane identifies several key strategic targets, linked to the SDGs.

Brisbane City Council's Clean Green Sustainable 2017 -2031[6] strategy is to elevate Brisbane to a 'top 10 lifestyle city globally'. This strategy aims incorporate references to waterway accessibility (Priority Action 6.2), and contribution to urban liveability (Priority Action 6.2).

Brisbane City Council's Access and Inclusion Plan: 2012-2017 [7] targets outdoor parks and natural areas with a focus on design for people of all ages and abilities to play together.

3 Current obstacles to interaction with waterways

To design new waterway parks in a manner that encourages and facilitates greater community interaction, it is critical to understand the key inhibiting factors that may prevent such interaction.

Literature on this topic, relating solely to waterways, is limited. Identification of obstacles to urban waterway interaction have therefore, been drawn from literature relating to park usage, urban safety and personal experience. Five key factors were developed including accessibility, perceptions of personal safety, attractiveness of the waterway, connectivity and water quality.

3.1 Accessibility

Accessibility of a waterway refers to how easily a person on foot can make direct contact with the water surface. This may include factors such as steepness of bank slopes and density of vegetation.

In many urban parks, accessibility will vary, providing a range of experiences to suit a range of physical ability levels. Accessibility of urban waterways should operate on similar principles.

Without sections of waterway bank that are of traversable grade, sufficiently clear of dense vegetation, interaction becomes challenging and limits access to only the most able and most bold.

3.2 Perceptions of personal safety

Recent fatal assaults in Brisbane and Melbourne have raised awareness of personal safety, especially for Australian women.

Public perception of personal safety may be a contributing factor to a lack of interaction with our green and blue spaces regardless of their accessibility and amenity. It is therefore vital to consider public safety not only with respect to physical hazards but from crime. CPTED (Crime Prevention Through Environmental Design) is a well-recognised acronym in the engineering industry.

It is noted that public perceptions of personal safety may not directly relate to the actual safety of a site based on crime statistics[8]. This design consideration is therefore based on how the site appears rather than based on analysis of crime statistics, although these may be a useful tool to understand key issues at an existing site.

3.3 Desirability of the waterway

Children today are three to four times more likely to be in front of a screen rather than playing sport in the 'critical window' between school and dinner. Research by the University of South Australia[9] found that unsurprisingly, the overwhelming competitor for physical activity was screen time. Importantly, the research found no evidence to suggest that children enjoy physical activity any less than previous generations. Time for physical activity is simply competing with other leisure options.

For natural play to compete for time in our busy, digital lives, the waterway park must be consciously 'designed' to be a desirable place to be. The attractiveness of the waterway may be judged by the presence of obvious play elements such as rocks to climb or throw, attractive vegetation or shade.

3.4 Connectivity

Connectivity of an urban waterway relates to the degree of connections from the site to formal and informal pathways. This may include placement of pedestrian or bike paths with the surrounding area as well as how the waterway affects pedestrian movements throughout the park.

Not all waterways need be connected through formal means. It is noted that the presence of pedestrian networks near to the waterways has the potential to increase incidental, spontaneous interaction en route to other locales. Pedestrian networks also provide additional recreational options for a combined trip such as jogging or walking to the shops.

3.5 Water quality

Water quality may affect the likelihood of interactions with waterways based on perceived health threats and enjoyment level. This is typically judged through either a visual assessment or odours.

Visual assessments may identify algae, turbidity or hydrocarbon spills. Odours may be because of sewer overflows. Sewer overflows occur when the sewerage system has insufficient capacity to contain sewage flows.

Touching and swimming in waterways subjected to sewage overflows, puts community health at risk. Local authorities often use temporary or permanent signage to alert the community to the possibility of sewage overflows.

With the prediction of more intense rain events in certain regions due to climate change, sewer overflows and contamination from failing sewer infrastructure may increase, resulting in increases in waterborne pathogen burdens in waterways[10].

3.6 Summary

Of the obstacles identified, those with the greatest potential for improvement of waterway interaction and within the realms of the designer's ability to change include:

- Perceptions of public safety;
- Ability to access the water; and
- Desirability of the waterway.

While an important obstacle to waterway interaction, reduction or removal of sewer overflows is considered outside of the scope of this investigation and is not considered further. Similarly, connectivity of the park to local networks is a broader park design consideration and not considered further.

Since the available literature in this field is limited, case study sites were investigated to provide verification of key waterway factors influencing interaction.

4 Brisbane region case studies

4.1 Purpose

The purpose of this case study investigation was to identify common features of existing popular waterways, nominated by community survey such that they may be reverse-engineered into design guidance.

4.2 Methodology

An informal community survey was undertaken over the period of approximately 2 years. The survey asked respondents to answer several questions relating to their usage and enjoyment of waterways in the South East Queensland region. Of key importance, was their recommendations of waterways that they enjoyed interacting with. The survey received over 60 responses and produced approximately 15 unique sites with which respondents regularly interacted. Further sites were added to this list based on observations over weekend periods and personal knowledge.

Each suggested site was physically inspected with notes and photos taken to answer several questions. Responses to these questions, paired with site photographs, were then used to draw conclusions as to what features made these sites popular for the community. Questions included:

1. Public safety: Do you feel personally safe to access the waterway?
2. Accessibility: Is access to the waterway possible? Does vegetation block your access? Are bank slopes easily traversable?
3. Connectivity: Is the site connected to pedestrian or bike paths?
4. X Factor questions: What fun things were there to do (e.g. throw rocks, chase lizards etc)

4.2 Key sites

Several sites nominated were excluded from the study as they were at major creek and river locations. These sites are not typically designed as constructed waterways and not relevant to this study.

Select sites are presented in Table 1 showing the relevant characteristics according to the three primary criteria developed: perceptions of personal safety (S), accessibility (A) and desirability (D).

Table 1: Key site features

Cedar Creek, QLD

- Variation in water depth (D)
- Rocks with which to play (D)
- Mixture of shade and open (D)(A)
- Good sight distance within creek (S)

Moore Park, Indooroopilly, QLD

- Low bank height (A) (S)
- Shallow water (A) (D)
- Good visibility to nearby pathways (S)

Cabbage Tree Creek, Everton Hills, QLD

- Low bank height (S)(A)
- Shallow water (A)
- Good shade cover (D)
- Good visibility to nearby pathways (S)

Bowman Park, (Frog Creek) Bardon, QLD

- Stepping stone weir structure (D)
- Aquatic life (D)
- Good visibility to nearby pathway (S)
- Low bank height (A)

Boundary Park, Arana Hills, QLD

- Moderate bank height (north bank), low bank height (south bank) (A)
- Shallow depth (D)(A)
- Sandy / gravel base (D)
- Aquatic life

Slaughter Falls, Mt Coot-tha, QLD

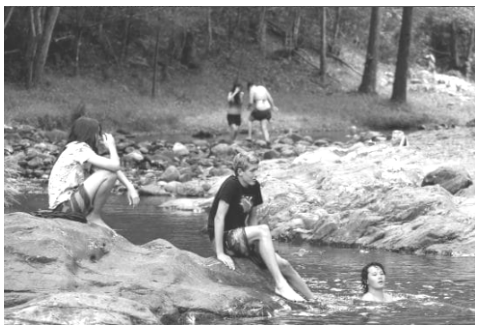
- Ephemeral (A)
- Low bank height (A)
- Good visibility (S)

Davidson Street, Newmarket, QLD

- Moderate bank height (A)
- Good visibility to nearby pathways (S)

Newly landscaped so unable to judge the site in its fully established form.

Currumbin Rock Pools, Currumbin, QLD



- Opportunities to swim, throw rocks (D)
- Mixture of shallow to deep water depth (D) (A)
- Open banks (S) but hidden from the road in areas

4.3 Case study findings

The recommended sites from the community survey shared similar features even though the location, vegetation and geomorphological features differed.

Frequently occurring features include:

- Low bank heights

Low bank heights improve sight lines between the water line areas and top of bank. This improves passive surveillance.

Bank heights were not exclusively low at each site however, the main access point to the site for interaction was typically observed from the low bank side.

Low bank heights may also improve accessibility by reducing the difficulty of traversing the banks. While the limited, current waterway design guidance for pedestrian access refers to bank slope, in practice, bank height may have a more limiting impact on accessibility.

- Shallow water

Shallow water depths provide a more attractive recreational option. This is partly due to the reasonably lower risk of drowning pared with the lower risk of getting really wet!

Shallow water may also provide aural interest in rocky streams as water trickles over rocks e.g. riffles.

- Rock features

Rocks can provide recreational opportunities through many different forms. Small rocks are good for throwing. Larger rocks may be stepping stones or good for climbing.

- Bank steepness

Bank steepness was not consistent across all sites. However, most sites had some sections with relatively flat slopes (e.g. flatter than 1V:4H) which provided easier access. This was often included via a cross-slope footpath that had been worn through continued use and infers that the community prefer flatter slopes to reach the waterway surface.

5 Waterway design standards gap analysis

A literature review was undertaken to determine the extent to which current waterway guidelines, focussing on the South East Queensland region, address the identified key factors / obstacles of personal safety, desirability and accessibility.

5.1 Perceptions of personal safety

Waterways in urban areas may affect personal safety through[11][12]:

- obstruction of sight lines and creation of concealment and entrapment places due to dense vegetation;
- Entrapment spots are small confined spaces close or adjacent to publicly accessible places. They are usually shielded on 3 sides by barriers such as walls or vegetation, and provide for easy concealment; and
- 'channelling' or 'tunnelling' of routes where deep or inaccessible waterways present a linear barrier.

The Living Waterways Framework[3] provides limited qualitative guidance and a recommendation to avoid concealed alcoves in communal gathering spaces, not waterway corridors, however, does not provide quantitative guidance on how to achieve it.

Current Australian waterway design guidelines including those from Melbourne Water[13], Brisbane City Council[14], Ipswich City Council, [15] omit reference to personal safety in their design criteria. These considerations are left to other aspects design such and generally covered within park design guidelines. Crime Prevention Through Environmental Design (CPTED) is the terminology most used to describe these design aspects.

This is a missed opportunity, considering that CPTED is not universally understood by designers and many projects would be undertaken independently from park design (e.g. waterway restoration projects).

A review of park design guidelines and CPTED-specific documents presents general guidance with regards to the provision of sight lines, passive surveillance and minimisation of concealment and entrapment spaces. The City of Gold Coast Park Design Guideline[11] included the most quantitative guidance including:

- Recommended minimum clear height before the lowest branch (for surveillance); and
- maximum vegetation height along pedestrian routes.

Current status: Most if not all Australian waterway guidelines do not adequately address personal safety. CPTED-specific guidelines and references in park design guidelines are also qualitative and provide very little design guidance.

Recommended design guidance required includes:

- quantitative guidance to improve passive surveillance to the water surface.

5.2 Accessibility

Waterway accessibility refers to the ability for pedestrians to access the water surface on foot. Accessibility is often limited by bank slope and density and type of vegetation.

The Queensland Urban Drainage Manual (QUDM)[16] addresses public safety with recommendations for a 'safety bench' of maximum 1V:8H within the first 0.3m of the waterway itself but does not address bank grades above the water surface.

Some waterway design guidelines make provisions for the need for pedestrians to traverse the banks such as the Ipswich Waterway and Channel Rehabilitation Guideline[15] which suggest a maximum slope of 1V:5H .

In practice, a 1V:5H slope is still not easily traversable by less-abled pedestrians. Further guidance on acceptable walking slopes is found in Australian Standard AS 2156.2 2001[17].

Current status: Some waterway guidelines provide guidance for accessible banks. However, the recommended bank slopes don't relate to bank height and may not be flat enough to allow access for less-abled pedestrians and at higher bank heights.

Recommended design guidance required includes:

- improved quantitative guidance regarding accessible bank slopes incorporating bank heights.

5.3 Desirability of the waterway

The desirability of the waterway refers to the attractiveness of the waterway for both passive and active recreation. This could be due to the visual attractiveness (i.e. colourful flowers, weed free nature), the aural value (i.e. creek riffles), or opportunities for natural play (i.e. lizards, rocks to throw and climb).

Waterway design guidelines do not currently address these factors. The Living Waterways Framework[3], addresses these social factors and enforces their value, however, stops short of definitive quantitative design guidance in many aspects. For example, it is advised to include:

- '*a variety of sensory vegetation connected with stormwater management systems within visitors / public users view and reach that provides a touch and / or visual value to the site's landscape;*
- inclusion of elements which provide *variety of sounds, rhythms and volume*s;
- *water management systems that draw attention to the 'line' of the stormwater trail; and*
- *design outcomes that allow users to touch the water systems in different forms such as flowing, falling and splashing*.

Current status: Waterway design guidelines do not address this issue; however, the Living Waterways Framework provides a good qualitative guidance for the inclusion of measures that could increase social value.

Recommended design guidance required includes:

- Quantitative guidance to achieve safe informal waterway crossings (i.e. "stepping stones"); and
- Greater guidance for desirable water depth to allow walking and wading.

6. Recommended design standards

This paper has identified several gaps between our strategic objectives for increased interaction with urban waterways and the current waterway design standards for South East Queensland.

To reduce the reliance on designer discretion, quantitative design guidance is proposed to fill these gaps.

All design recommendations presented are recommendations only and must be approved through consultation with local approving authorities and used in conjunction with existing waterway design guidelines.

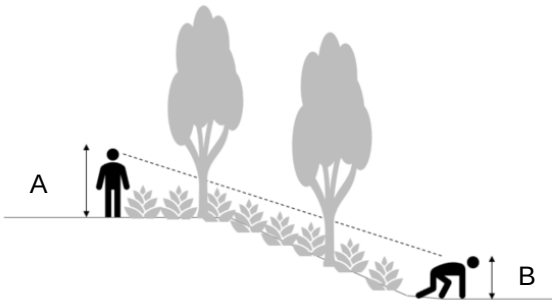
6.1 Proposed personal safety standards

Waterway design which considers personal safety, as opposed to physical safety (e.g. fall heights), should consider the following design elements:

- Provision of passive surveillance in balance with ecological needs

Table 2 provides quantitative standards to achieve increased passive surveillance to the waterway surface.

Table 2 Safer waterway design guidelines

Design Element	Recommendation
Visibility of the waterway	All design criteria should be replaced with a single guidance principle: A nominal person (A = 1.5m) walking at the top of bank edge of landscaping, should be able to see a person at a B = 1.0m) at the waterway edge of the nearest bank. Refer figure below.
	
Park design guidelines often include dimensions for lowest branch height of trees, but these criteria do not translate well to a sloped waterway bank and do not provide sufficient line of sight. *Removal of the 'middle layer' of vegetation in accessible locations may reduce the ecological value of the site. It is intended that accessible waterway dimensions will be applied at select locations with careful consideration given to preservation and creation of habitat for ecological value.*	
Minimum sight distance	15m
Sight distance refers to the ability of users of accessible waterways to see the path ahead and differs from the waterway visibility. Based on the City of Gold Coast Park Design Guideline [11[. *Includes accessible waterway locations as well as access tracks to accessible areas.* *Sight may be filtered through tree trunks but should exclude dense shrubs.*	

In addition to these standards, it is recommended that a CPTED assessment be undertaken for all urban waterway design projects to ensure other qualitative considerations such as avoidance of entrapment and concealment points, lighting and broader surveillance issues are considered and addressed.

6.2 Proposed accessibility standards

Accessible waterways must balance accessible bank dimensions with other project constraints such as cost, location of underground services and project boundaries. It is not necessary to have accessible bank slopes in all locations of the waterway. Accessible bank slopes should be located at areas of interest (e.g. rock riffles or stepping stones).

Table 3 provides quantitative standards to achieve increased physical accessibility of the waterway surface.

Table 3 Accessible waterways design guidelines

Design Element	Recommendation
Bank slope	No limit for bank height ≤ 0.3m 1V:5H for bank height 0.3 - 0.5m 1V:8H for bank height > 0.5m
For designated 'accessible' areas only. *1V:5H bank slope is based on recommended slope for Ipswich Waterway and Channel Rehabilitation Guideline[15].* *1V:8H bank slope is equivalent to a Class 2 walking track. Refer AS 2156.2 2001[17].*	
Maximum bank height	1.0-1.5m
Popular waterway sites typically have at least one accessible bank side with low bank height. Where bank height exceeds 1.5m, consider benching.	

6.3 Proposed desirability standards

Typical design measures to be considered to improve the desirability of the waterway for passive or active recreation include:

- informal waterway crossings such as stepping stones
- inclusion of flowering or otherwise eye-catching vegetation
- selection of smooth edged rocks which vary in size in preference to uniformly sized, jagged rocks as are typically used for scour protection
- consideration to audible sections of the waterway such as rock riffles or small steps within the waterway

For further guidance regarding the types of features which may add to the desirability of a waterway, refer to the Living Waterways Framework.

Any features which involve obstructions of the waterway, such as stepping stone, should consider fish passage requirements where applicable. Fish passage requirements should not preclude the inclusion of these design elements, but they should be considered together.

Table 4 provides quantitative standards to achieve more attractive waterways which invite interaction.

Table 4 Informal waterway crossing design guidelines ("stepping stones")

Design Element	**Recommendation**
Adjacent water depth (2m upstream and downstream from crossing)	0.5m – 0.3m desirable 1.0m maximum
Where no fish passage is required, this depth has no lower limit. *Where fish passage requirements demand a depth > 1.0m, co-location of an adventure crossing is not recommended.*	
Flood immunity	Less than that of the formal pathway system or 1 in 1-year ARI, whichever is the lesser.
Stepping stones should have a flood immunity less than that of the formal pathway network. It is important that the stepping stones are not accessible during times of flood where they appear the only option to cross the waterway.	
Depth-Velocity (dV)product	0.6 m^2/s in the design event for the stepping stones.
0.6m^2/s is considered a minimum target to show compliance with current local council design standards[18]. Higher dV values may be appropriate for areas which appear obviously 'natural' and where a higher risk may be accepted and anticipated. *Higher depth-velocity products may be appropriate where flow depths are less than 0.3m.*	
Spacing between steps / rocks	0.3m – 0.6m desirable
Rock spacing should be irregular and imitate a natural stream placement where possible. Spacing between rocks should be on the lower limit for sites heavily utilised by children. *The crossing should not appear heavily engineered or unnatural.*	
Rock / step size	≥ 0.3m
Rock sizing should be irregular, but preference given to rocks with a flattish top to allow for more stable footing and fewer hazards upon impact. Minimum rock size is selected to allow for comfortable placement of a foot.	

7 Conclusions

This research suggests that social wellbeing outcomes are not adequately incorporated into current waterway design guidelines applicable to the Brisbane region, and likely beyond.

Without quantitative design guidance, achievement of social outcomes will rely on the discretion and empathy of the designer. This

may reduce the likelihood of urban waterways providing social wellbeing outcomes.

It is recommended that waterway design guidelines enforced by approving authorities be updated to incorporate quantitative measures for social wellbeing outcomes as proposed in this paper.

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