Green Bridges Expert Panel Report on Maritime Safety Impacts for Sailing, Rowing and Paddling on the St Lucia, Toowong and Milton Reaches of the Brisbane River

31 March 2021

Contents

SUMMARY

The Milton, Toowong and St Lucia reaches of the Brisbane River are frequently used and historically significant sections of waterway that are integral to the ongoing viability and vitality of Brisbane's watersports including rowing, sailing and paddling (i.e., canoeing, kayaking, dragon boat racing etc). Several long-established community and school watersport clubs are located on the Milton and Toowong reaches. The reaches are also popular with unaffiliated community users.

'Green Bridges' proposed by the Brisbane City Council between Toowong and West End and between St Lucia and West End would present a significant risk to the safety of rowers, sailors and other river users if the design and location of the proposed bridges does not take adequate account of risk of vessel-to-vessel collision and vessel to bridge collision.

The possible safety impacts that should be considered in design of Green Bridges are:

a) Serious injury, possible fatality, drowning and irreparable damage to vessels as a result of rowing, sailing or paddling boat collision with bridge piers due to navigational error, lower visibility and increased turbulence;
b) Serious injury, possible fatality, drowning and irreparable vessel damage as a result of powered vessel impact with rowing, sailing or paddling boats near bridges due to navigational error, lower visibility and increased turbulence; and
c) Serious injury, possible fatality, drowning and irreparable vessel damage as a result of powered vessel impact bridge piers due to navigational error, lower visibility and increased turbulence.

Environmental and human factors that are likely to contribute to impacts include:

- Inexperience and age of boat skippers, coxswain or captains,
- Strong current,
- High winds, low winds and wind turbulence,
- Coincident passage under bridge by powered vessels and rowing, sailing or paddling craft,
- Wash and wave action from powered vessels, and
- Other marine hazards such as debris.

These impacts would increase in proportion to the number of piers as follows:

- Nil piers (single span bridge) - No or negligible safety impacts,
- One pier (two span bridge) - Moderate to high risk (dependant on pier placement and other risk mitigation measures), and
- Two or more piers (three or more span bridge) - High / unacceptable risk to human safety.

The likelihood of safety impacts and river utilisation for established users is listed below in order from the highest risk to least risk. This ranking does not reflect risks regarding bridge piers.

1. Highest risk: Toowong to West End Option C
2. Second greatest risk: Toowong to West End Option B
3. Third highest risk: Toowong to West End Option A
4. Fourth highest risk: St Lucia to West End Option C.
5. Fifth highest risk: St Lucia to West End Option A.
6. Sixth highest (least) risk: St Lucia to West End Option B.

The need for consideration of these safety impacts is also specified in the Queensland Government's State Code 7 regarding maritime safety[1] which requires that 'Development does not impede the safe movement of vessels in a navigable waterway.'

In addition to consideration of collisions in structural integrity and safety of bridge users, it is also recommended that collision analysis also take into account possible loss of life and injury that would result from collision between rowing boats, sailing boats and other non-powered watercraft.

It is recommended that any design brief for the proposed Green Bridge take into account recent collisions including:

- Kookaburra Queen Boat crash with the William Jolly Bridge (29 Oct 2009) [2]
- Kookaburra Queen Boat crash with Goodwill Bridge (April 2004) [3]
- CityCat collision with rowing boat (1 June 2015)[4]
- CityCat collision with rowing boat (12 June 2012)[5]
- CityCat collision with rowing boat (16 Aug 2005)[6]

The 'standard navigational channel width' of 70 meters suggested by Brisbane Council based on prior advice from Regional Harbourmaster is not applicable to the design of bridges on the Milton, Toowong or St Lucia reaches of the Brisbane River, in view of the high use by rowing craft, paddling craft, sailing craft, powered recreational and commercial vessels. It is implausible that a standard width of 70 meters would ensure safety outcomes that are consistent with State Code 7 regarding Maritime Safety requiring that "Development does not impede the safe movement of vessels in a navigable waterway."

In addition to safe design criteria required by Queensland Legislation and Australian Standards, community interests and interests of rowing, sailing, paddling users of the Milton, Toowong or St Lucia reaches of the Brisbane River would be protected by adoption of the additional design principles recommended by in the publication *Knott, M., Pruca, Z. "Vessel Collison Design of Bridges." Bridge Engineering Handbook. Ed. Wai-Fah Chen & Lian Duan Boca Raton: CRC Press, 2000*.

A solution which would resolve likely maritime safety impacts as described is to adopt a single span design with piers no more than 5 meters off the banks. A practical example of such a design is the famous "Three Countries Bridge" which crosses the Rhine between France and Germany. It is the world's longest single-span bridge dedicated to pedestrians and cyclists with a main span of 229.4 meters[7]. Most of the proposed 'Green Bridge' crossing options are within this span width.

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[1] https://planning.dsdmip.qld.gov.au/planning/better-development/the-development-assessment-process/the-states-role/state-development-assessment-provisions

[2] https://www.brisbanetimes.com.au/national/queensland/brisbane-river-boat-in-bridge-collision-20091029-hljj.html

[3] https://amp.couriermail.com.au/news/queensland/paddlewheeler-kookaburra-queen-hits-william-jolly-bridge/news-story/bc570b16a3828693724db565885112bb

[44] https://www.brisbanetimes.com.au/national/queensland/citycat-crashes-into-rowers-on-brisbane-river-20150601-ghdt1x.html

[5] https://www.brisbanetimes.com.au/national/queensland/teen-rower-severely-injured-in-citycat-collision-20120612-206js.html

[6] https://www.abc.net.au/news/2005-08-16/investigation-begins-into-brisbane-river-collision/2082054

[7] https://en.wikipedia.org/wiki/Three_Countries_Bridge

1 Introduction

The Milton, Toowong and St Lucia reaches of the Brisbane River are frequently used and historically significant sections of waterway used by a number of watersports including rowing, sailing, and paddling (i.e., canoeing, kayaking, dragon boat racing etc). Several long-established water-based Community and School Sporting Clubs are located on the Milton and Toowong reaches. The reaches are also popular with unaffiliated community users, as echoed by the Brisbane City Council policy to promote river access for recreational purposes[8].

'Green Bridges' proposed by the Brisbane City Council between Toowong and West End and between St Lucia and West End would present a significant risk to the safety of rowers, sailors and other river users if design of the proposed bridges does not take adequate account of risk of vessel-to-vessel collision and vessel to bridge collision.

This report presents a summary of these maritime safety risks and outlines a number of design principles to address concerns, and an acceptable solution which would provide planning certainty and ensure compliance with Queensland's State Planning Policies on Maritime Safety.

2 Likely safety impacts

The most likely safety impacts of Green Bridges on rowing, sailing and paddling are:

a) Serious injury, possible fatality, drowning and significant damage to vessels as a result of rowing, sailing or paddling boat collision with bridge piers, due to navigational error, low visibility and increased turbulence;
b) Serious injury, possible fatality, drowning and significant vessel damage as a result of powered vessel impact with rowing, sailing or paddling boats near bridges due to navigational error, low visibility and increased turbulence;
c) Serious injury, possible fatality, drowning and significant vessel damage as a result of powered vessel impact with bridge piers due to navigational error, low visibility and increased turbulence.

An example of the type of impact experienced between a bridge pier and a rowing boat is demonstrated by a 2014 bridge crash in Oregon, USA (Figure 1)[9]. Similar events have occurred on the Grey Street Bridge piers at the north eastern end of the Milton reach.

Environmental and human factors that are likely to contribute to these impacts include:

- Inexperience and age of boat skippers, coxswain or captains,
- Strong current,
- High winds, low winds and wind turbulence,
- Coincident passage under bridge by powered vessels and rowing, sailing or paddling craft,
- Wash and wave action from powered vessels, and
- Other marine hazards such as debris.

[8] https://www.brisbane.qld.gov.au/things-to-see-and-do/outdoor-activities/boating-canoeing-and-fishing/public-river-and-recreation-hubs-boat-ramps-canoe-ramps-and-pontoons/river-access-network
[9] https://www.youtube.com/watch?v=a35_0dXyECY

Figure 1. Example of bridge pier impact by rowing boat

3 Risk of alternative bridge locations and design options

The likelihood of safety impacts and river utilisation for established users is greatest for bridge options nearest the Area of Caution is as listed below. This ranking does not reflect risks regarding the number of bridge piers.

1. Highest risk: Toowong to West End Option C
2. Second greatest risk: Toowong to West End Option B
3. Third highest risk: Toowong to West End Option A
4. Fourth highest risk: St Lucia to West End Option C.
5. Fifth highest risk: St Lucia to West End Option A.
6. Sixth highest risk: St Lucia to West End Option B.

It should be noted that Toowong to West End Option C is also immediately adjacent to the South Brisbane Sailing Club and may present a high risk to boats leaving this boat ramp. Similarly, the Toowong Rowing Club is in close proximity to the St Lucia to West End Option C.

The above impacts would increase in proportion to the number of bridge piers as follows:

- Nil bridge piers (single span bridge) - No or negligible safety impacts
- One bridge pier (two span) - Moderate to high risk (dependant on pier placement and other risk mitigation measures): (See Appendix A), and
- Two or more bridge piers (three or more spans) - High / unacceptable risk to human safety.

The proximity of all Toowong to West End Bridge options to the “Area of Caution” between the St Lucia and Milton Reaches of the Brisbane River, between approx. Montague Road and Drury St West End (Appendix B) is of high concern because of the increased likelihood of vessel-to-vessel impact as a result of restricted visibility combined with restricted CityCat movements near the Regatta Ferry Terminal.

4 Queensland development and design requirements

The need for consideration of these safety impacts is also specified in the Queensland Government's State Code 7 regarding maritime safety[10] which requires that 'Development does not impede the safe movement of vessels in a navigable waterway.'

In order to comply with requirements of the Queensland Department of Transport manual on Design Criteria for Bridges and Other Structures (Appendix A Item 50), it is recommended that usage patterns of rowing boats, sailing boats and other non-motorised vessels be included in collision analysis in order to give "due consideration of all vessels currently operating in the waterway or likely to operate in the waterway for the next 100 years." [11]

In addition to consideration of collisions in structural integrity and safety of bridge users, it is also recommended that collision analysis also take into account possible loss of life and injury that would result from collision between rowing boats, sailing boats and other non-powered watercraft.

It is recommended that any design brief for the proposed Green Bridge take into account recent collisions including:

- Kookaburra Queen Boat crash with the William Jolly Bridge (29 Oct 2009) [12]
- Kookaburra Queen Boat crash with Goodwill Bridge (April 2004) [13]
- CityCat collision with rowing boat (1 June 2015)[14]
- CityCat collision with rowing boat (12 June 2012)[15]
- CityCat collision with rowing boat (16 Aug 2005)[16]

The 'standard navigational channel width' of 70 meters suggested by Brisbane Council based on prior advice from Regional Harbourmaster is not applicable to the design of bridges on the Milton, Toowong or St Lucia reaches of the Brisbane River, in view of the high use by rowing craft, canoes, river kayaks, sailing craft, powered recreational and commercial vessels. It is implausible that a standard width of 70 meters would ensure safety outcomes that are consistent with State Code 7 regarding Maritime Safety requiring that "Development does not impede the safe movement of vessels in a navigable waterway."

5 Suggested safe design criteria

In addition to safe design criteria required by Queensland Legislation and Australian Standards, community interests and interests of rowing, sailing and paddling users of the Milton, Toowong or St Lucia reaches of the Brisbane River would be protected by adoption of the additional design

[10] https://planning.dsdmip.qld.gov.au/planning/better-development/the-development-assessment-process/the-states-role/state-development-assessment-provisions
[11] https://www.tmr.qld.gov.au/-/media/busind/techstdpubs/Bridges-marine-and-other-structures/Bridge-design-and-assessment-criteria-manual/DesignCriteriaforBridgesandOtherStructures.pdf?la=en
[12] https://www.brisbanetimes.com.au/national/queensland/brisbane-river-boat-in-bridge-collision-20091029-hljj.html
[13] https://amp.couriermail.com.au/news/queensland/paddlewheeler-kookaburra-queen-hits-william-jolly-bridge/news-story/bc570b16a3828693724db565885112bb
[1414] https://www.brisbanetimes.com.au/national/queensland/citycat-crashes-into-rowers-on-brisbane-river-20150601-ghdt1x.html
[15] https://www.brisbanetimes.com.au/national/queensland/teen-rower-severely-injured-in-citycat-collision-20120612-206js.html
[16] https://www.abc.net.au/news/2005-08-16/investigation-begins-into-brisbane-river-collision/2082054

principles recommended by in the publication *Knott, M., Pruca, Z. "Vessel Collison Design of Bridges." Bridge Engineering Handbook. Ed. Wai-Fah Chen and Lian Duan Boca Raton: CRC Press, 2000,* as listed below.

a) Bridges should be located away from turns in the channel. The distance to the bridge should be such that vessels can line up before passing the bridge, usually at least eight times the length of the vessel. An even larger distance is preferable when high currents and winds are likely to occur at the site.
b) Bridges should be designed to cross the navigation channel at right angles and should be symmetrical with respect to the channel.
c) An adequate distance should exist between bridge locations and areas with congested navigation, port facilities, vessel berthing manoeuvres, or other navigation problems.
d) Locations where the waterway is shallow or narrow so that bridge piers could be located out of vessel reach are preferable.
e) The selection of the type and configuration of a bridge crossing should consider the characteristics of the waterway and the vessel traffic, so that the bridge would not be an unnecessary hazard to navigation. The layout of the bridge should maximize the horizontal and vertical clearances for navigation, and the bridge piers should be placed away from the reach of vessels.
f) Finding the optimum bridge configuration and layout for different bridge types and degrees of protection is an iterative process which weighs the costs involved in risk reduction, including political and social aspects.
g) The characteristics of the waterway in the vicinity of the bridge site such as the width and depth of the navigation channel, the current speed and direction, the channel alignment and cross section, the water elevation, and the hydraulic conditions, all have a great influence on the risk of vessel collision and must be taken into account.
h) The presence of bends and intersections with other waterways near the bridge increases the probability of vessels losing control and become aberrant. The navigation of downstream barge tows through bends is especially difficult.
i) The vessel transit paths in the waterway in relation to the navigation channel and the bridge piers can affect the risk of aberrant vessels hitting the substructure.
j) Water currents at the location of the bridge can have a significant effect on navigation and on the probability of vessel aberrancy. The design water currents commonly used represent annual average values rather than the occasional extreme values that occur only a few times per year, and during which vessel traffic restrictions may also apply.
k) General knowledge on the operation of vessels and their characteristics is essential for safe bridge design.
l) The vessel data required for bridge design include types of vessels and size distributions, transit frequencies, typical vessel speeds, and loading conditions. In order to determine the vessel size distribution at the bridge site, detailed information on both present and projected future vessel traffic is needed.
m) Due to economic and structural constraints, bridge design for vessel collision is not based on the worst-case scenario, and a certain amount of risk is considered acceptable.
n) The risk acceptance criteria consider both the probability of occurrence of a vessel collision and the consequences of the collision. The probability of occurrence of a vessel collision is affected by factors related to the waterway, vessel traffic, and bridge characteristics. The consequences of a collision depend on the magnitude of the collision loads and the bridge strength, ductility, and redundancy characteristics. In addition to the potential for loss of life, the consequences of

a collision can include damage to the bridge, disruption of motorist and marine traffic, damage to the vessel and cargo, regional economic losses, and environmental pollution.

o) Acceptable risk levels have been established by various codes and for individual bridge projects. The acceptable annual frequencies of bridge collapse values used generally range from 0.001 to 0.0001. These values were usually determined in conjunction with the risk analysis procedure recommended and should be used accordingly.

p) Incorporation of the risk of vessel collision and cost of protection in the total bridge cost has almost always resulted in longer span bridges being more economical than traditional shorter span structures, since the design goal for developing the bridge pier and span layout is the least cost of the total structure (including the protection costs). Typical costs for incorporating vessel collision and protection issues in the planning stages of a new bridge have ranged from 5% to 50% of the basic structure cost without protection.

q) Experience has also shown that it is less expensive to include the cost of protection in the planning stages of a proposed bridge, than to add it after the basic span configuration has been established without considering vessel collision concerns. Typical costs for adding protection, or for retrofitting an existing bridge for vessel collision, have ranged from 25% to over 100% of the existing bridge costs.

In addition to implementing bridge design controls, additional maritime safety controls would also help to mitigate risks to rowers, sailors and paddles. These controls would include but are not limited to:

- Speed controls for powered vessels (e.g., reduce to 6 knots within 250m of bridges), and
- Maritime traffic direction by use of special markers.

6 Recommended design solutions

A solution which would resolve likely maritime safety impacts as described is to adopt a single span design with piers no more than 5 meters off the banks, as depicted in **Figure 2**.

A practical example of such a design is the famous “Three Countries Bridge” which crosses the Rhine between France and Germany within a metropolitan area of Switzerland (Figure 3). It is the world's longest single-span bridge dedicated to pedestrians and cyclists with a main span of 229.4 meters[17]. Most of the proposed ‘Green Bridge’ crossing options are within this span width.

Figure 2. *Proposed single span “green bridge” design*

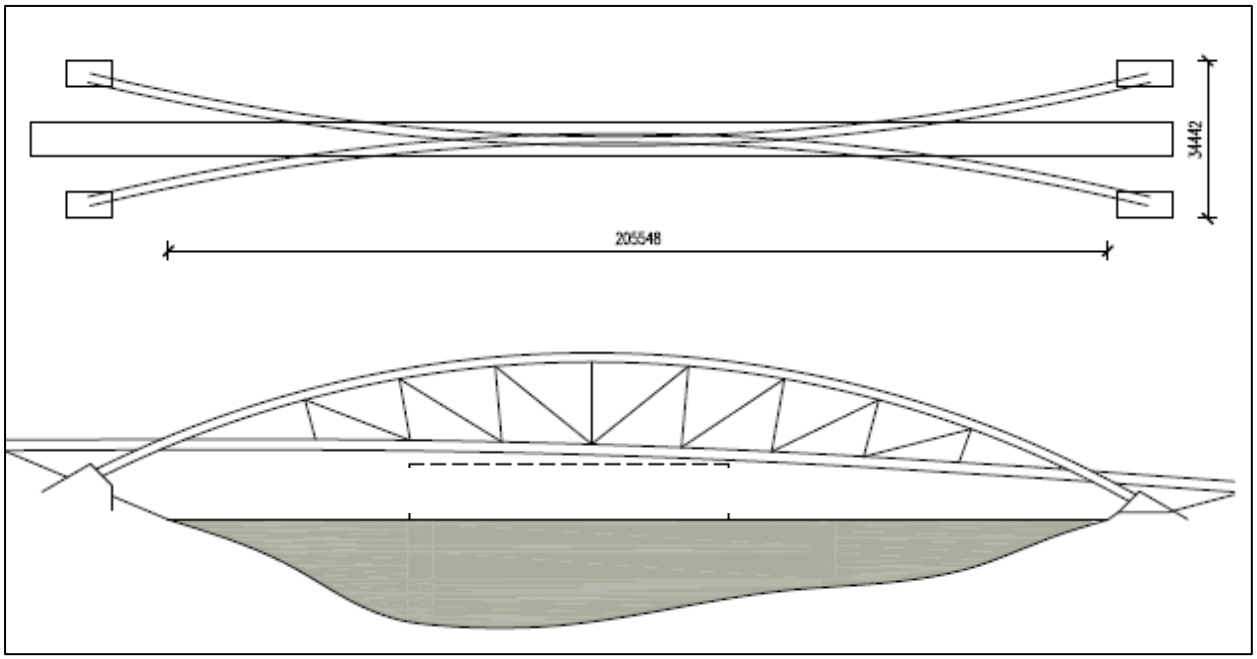

Figure 3. “Three Countries Bridge” single-span bridge dedicated to pedestrians and cyclists

[17] https://en.wikipedia.org/wiki/Three_Countries_Bridge

7 Conclusions

Of proposed Green Bridges crossings, Option B between St Lucia and West End would present the least impact to rowing, sailing and other non-motorised watercraft. Of proposed bridge locations between Toowong and West End, Option C would have highest safety impact and Option A would have least safety impact.

Safety impacts would increase in proportion to the number of piers where a single span bridge with no piers would have no or negligible safety impacts, a two-span bridge would have moderate to high risks, and a bridge with tree or more spans would have high and unacceptable risk to human safety.

A design solution which would resolve likely maritime safety impacts as described is to adopt a single span construction with piers no more than 5 meters of the banks. This design solution would have greatest certainty of meeting Queensland Planning Maritime Safety requirements.

8 Expert Panel Membership

Robert Preston BSc GCSocRes, MEnv
Chair, Expert Panel on Maritime Safety
President, South Brisbane Sailing Club
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Ian Holzberger BSc GeoSc, Math, Dip Proj Mgt
CEO Rowing Queensland,
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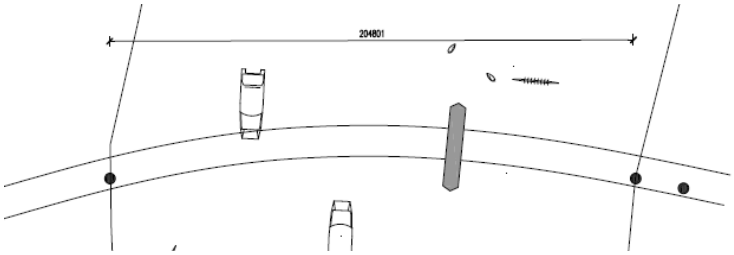
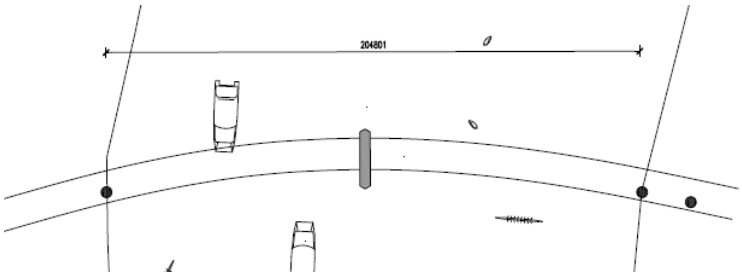
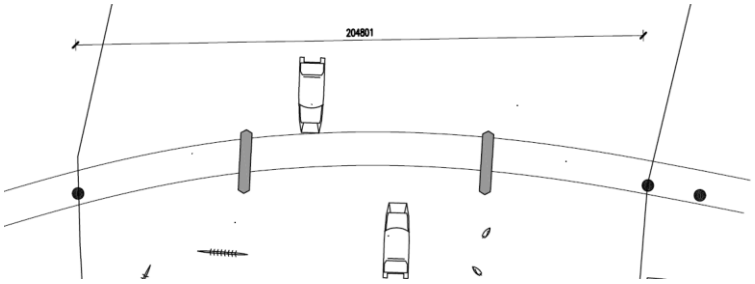
Stephen McDonald BE
President, West End Canoe Club

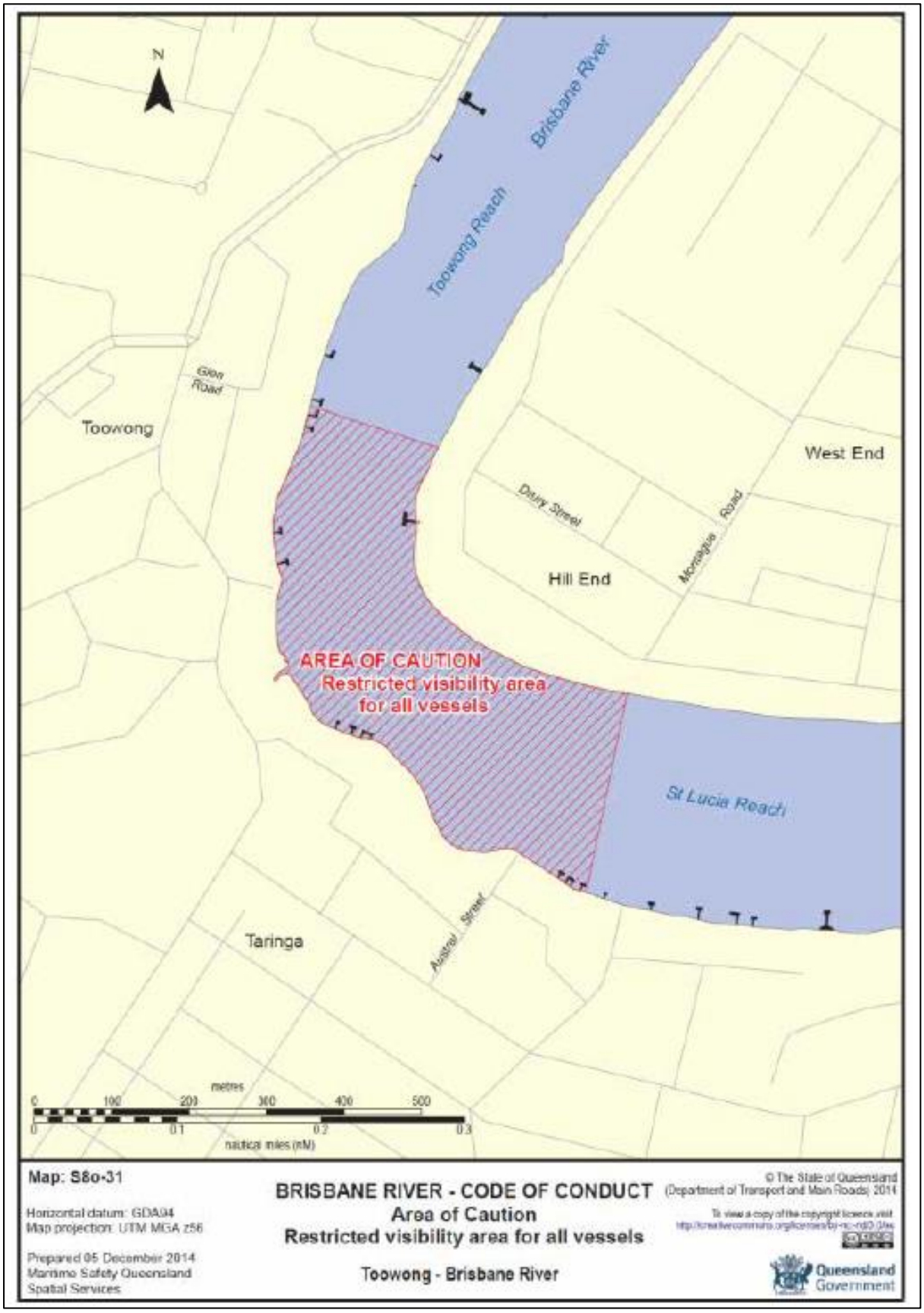
Ben Callard BSMSM, GradDipEd
Regional Manager (Queensland)
Australian Sailing

John Price BArch(Hons), AIA, RYA Yachtmaster
Senior Sailing Instructor,
South Brisbane Sailing Club

9 Appendix A. Single and two pier risk analysis

Bridge Option	*Likely risks*
(i) Single pier towards eastern bank 	• Moderate likelihood of collision between to cross-river rowing and sailing craft and powered craft • Moderate likelihood rowing and sailing craft collision with bridge pier
(ii) Single pier towards middle of river 	• Moderate likelihood of collision between to cross-river rowing and sailing craft and powered craft • Moderate likelihood rowing and sailing craft collision with bridge pier
(iii) Two pier design 	• High likelihood of collision between to cross-river rowing and sailing craft and powered craft • High likelihood rowing and sailing craft collision with bridge pier

10 Appendix B. Area of Caution – West End Peninsula



Source: Brisbane River Code of Conduct, Maritime Safety Queensland (2014)