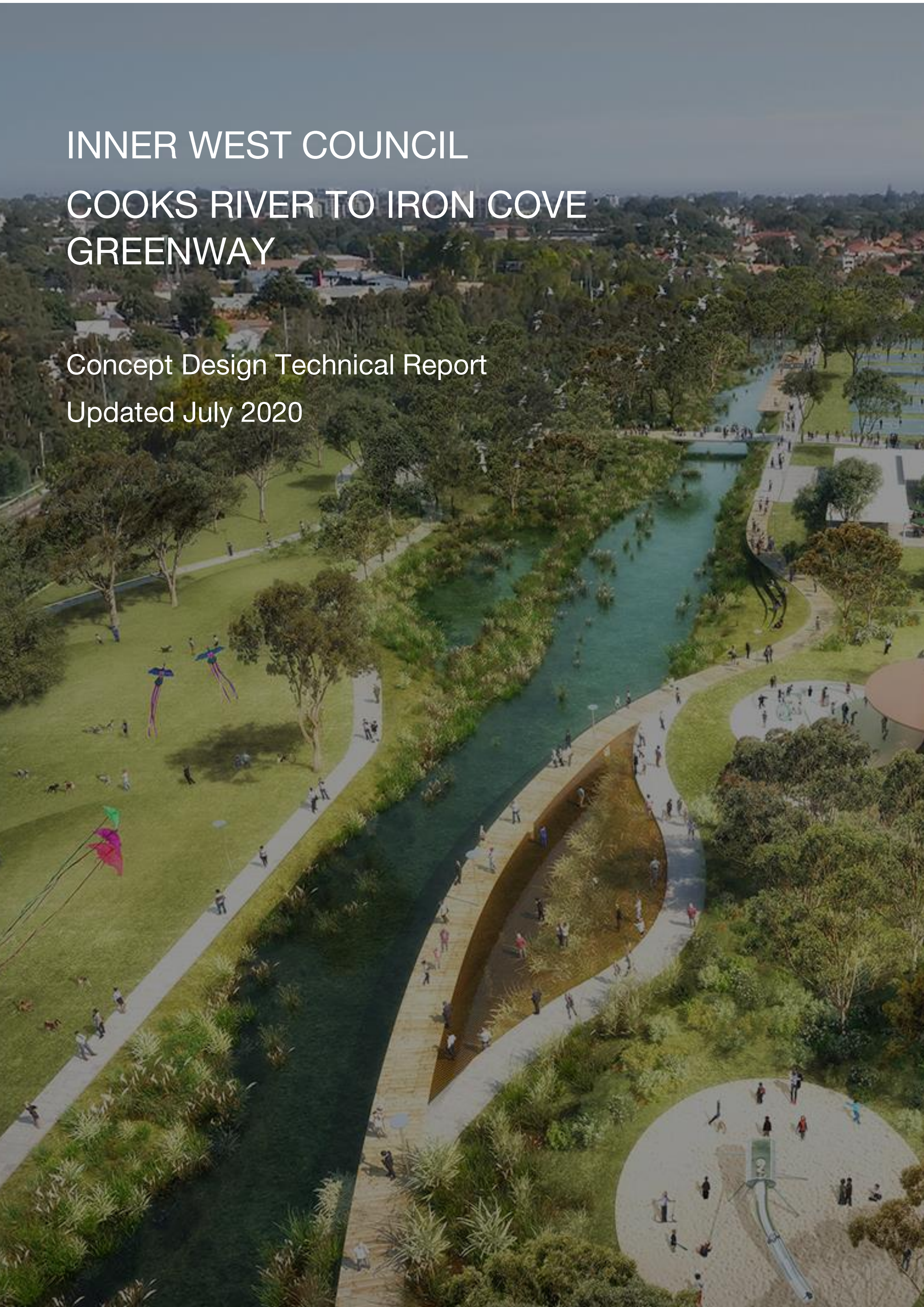
INNER WEST COUNCIL

COOKS RIVER TO IRON COVE GREENWAY

Concept Design Technical Report

Updated July 2020



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- JACOBS MEMORANDUM RE ROAD CROSSING OPTIONS ON THE GREENWAY, 21 DEC 2018

APPENDIX B: STRUCTURAL ENGINEERING ADVICE

- SDA STRUCTURAL REPORT: LILYFIELD ROAD BRIDGE, 20 DEC 2018
- SDA LETTER REPORT RE CONSTITUTION ROAD TO NEW CANTERBURY ROAD – PRELIMINARY SCHEME FOR COSTING, 31 JAN 2019 AND DRAWINGS SK10-18
- DRAWINGS FOR CENTRAL LINKS: SK1-16

APPENDIX C: LIGHTING DESIGN REPORT

- LIGHTING ART AND SCIENCE GREENWAY MISSING LINKS CONCEPT DESIGN REPORT, UPDATED JULY 2020

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- INNER WEST COUNCIL MEMO, 15 SEP 2017

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- TLB GAS MAIN OPTIONS REPORT – 23 JULY, 2018
- TLB BRIDGE GIRDER ASSESSMENT REPORT – 23 JULY, 2018

LILYFIELD ROAD BRIDGE

1 INTRODUCTION

This report provides technical information on the concept design for the GreenWay, to accompany concept design drawings and inform further design development

Inner West Council adopted the GreenWay Master Plan in August 2018, and are now proceeding with design development for the following sections:

- The southern links, from the Cooks River to Old Canterbury Road
- The central links, from Old Canterbury Road to Parramatta Road
- Richard Murden Reserve, from Marion Street to Iron Cove

McGregor Coxall has been commissioned to develop concept designs for each of these sections. The concept design scope is detailed further below.

This concept design report has been developed to accompany McGregor Coxall's concept design drawings, to provide information on:

- Background information which has informed the concept design
- Input from stakeholders
- Important assumptions made in the concept design development process
- Analysis undertaken
- Recommendations on further investigations recommended to inform detailed design

1.1 THIS PROJECT

McGregor Coxall's concept design scope includes a new/upgraded shared path between the Cooks River and Parramatta Road, and between Marion Street and Iron Cove, as well as new/upgraded open spaces at Dulwich Grove, Johnson Park, Lewisham West, Gadigal Reserve and the Lilyfield Road bridge.

The following specific elements are covered in this report:

Off-road shared paths

- Cooks River to Garnet Street: option through western edge of Marrickville Golf Course alongside Tennent Pde
- New path from Hercules Street (southern end) to Johnson Park
- New path from Johnson Park to Weston Street
- New path through Lewisham West from Old Canterbury Road to Longport Street
- New path through Gadigal Reserve, from Longport Street to Parramatta Road
- Path upgrade through Richard Murden Reserve from Marion Street to Iron Cove
- Section of the Bay Run from Lilyfield Road bridge to UTS Haberfield Club

On-road links (and associated traffic works)

- Tennent Pde bike boulevard/separated cycleway options
- Garnet Street bike boulevard/separated cycleway options
- Ness Avenue bike boulevard
- Terrace Road-Hercules Street roadside shared path
- Weston Street bike boulevard

Other traffic works

- Riverside Crescent partial road closure
- Ewart Street intersection upgrade
- Hercules Street at-grade crossing upgrade
- Northern Canal Road shared zone
- Lilyfield Road intersection (western end of Lilyfield Road) upgrade

Tunnels

- Constitution Road

- Davis Street
- Longport Street

Elevated structures

- Elevated shared path from Hercules Street to Constitution Road (including underpass under New Canterbury Road)
- Elevated shared path from Longport Street to Parramatta Road (including underpass under Parramatta Road)
- Lilyfield Road bridge

Waterways, stormwater and WSUD

- Creek and wetland restoration at Dulwich Grove
- Terry Street drainage improvements
- Wetland at Lewisham West
- Channel bank restoration at Gadigal Reserve
- Seawall works at Iron Cove
- Streetscape drainage and rain gardens (various locations) associated with traffic treatments

Light rail corridor interface

- Rail corridor boundary changes
- Vegetation requirements
- Access requirements

Other Services

- Site-specific issues related to buried services

Note that there are also appendices covering traffic engineering, structural design and lighting design.

1.2 OVERVIEW OF THIS REPORT

This report steps through each of the above elements and includes the following:

- Design principles applied to these elements
- Relevant standards, guidelines and examples
- Site-specific design considerations
- Typical details and examples

2 OFF ROAD SHARED PATHS

Where the main GreenWay path is an off-road shared path, the principal design guideline is Austroads Part 6A (2017). There are also some additional considerations to achieve an outcome compliant with AS 1428.1:2009 – Design for Access and Mobility

2.1 LOCATIONS

Off-road shared paths are proposed in the following locations:

- Cooks River to Garnet Street: option through western edge of Marrickville Golf Course alongside Tennent Pde
- New path from Hercules Street (southern end) to Johnson Park
- New path from Johnson Park to Weston Street
- New path through Lewisham West and Gadigal Reserve, from Old Canterbury Road to Parramatta Road
- Path upgrade through Richard Murden Reserve from Marion Street to Iron Cove
- Section of the Bay Run from Lilyfield Road bridge to UTS Haberfield Club

Note that some of these sections will be elevated, and some at grade.

2.2 DESIGN PRINCIPLES

The Master Plan established that the main GreenWay path should generally be:

- A shared pedestrian and bike path
- 3.5 m minimum width (4.0 m recommended through parks with higher traffic)
- Accessible to all users
- With lighting

The Master Plan recommended the following path materials:

- Where at-grade, a concrete path is recommended
- Where elevated, FRP decking is recommended

The Master Plan also made the following suggestions about design of the off-road paths:

- Design the shared path to read as a recreational route (acknowledging it will also be used by commuters)
- A design speed for bikes of 20 km/hr
- Provide more space at busy nodes and links
- Adopt shared path linemarking styles and symbology being utilised in the City of Sydney
- Provide rest stops at 200-400 m intervals (preferably 200 m where achievable)

2.3 GUIDELINES AND STANDARDS

The key guideline used for concept design has been the Austroads “Guide to Road Design Part 6A – Paths for Walking and Cycling” (2017), with other references where noted.

In addition, the intention is to design the main GreenWay path and key connections to comply with AS 1428.1:2009 – Design for Access and Mobility.

2.3.1 PATH WIDTH

As noted above, the recommended minimum width for the main GreenWay path is recommended as 3.5 m.

The existing path in Johnson Park is 4.0 m wide. No change is proposed as part of the concept design.

Within other park areas within the concept design scope, 3.5 m is considered a reasonable width, for the following reasons:

- Around Richard Murden Reserve, there are multiple route options including Hawthorne Parade, which will take some of the faster bike traffic
- The Hercules Street open space is unlikely to attract as much traffic as the larger more active park areas

Note that the concept design also includes a section of Bay Run path to be upgraded. The established template for other upgraded sections of the Bay Run is a total 4.8 m path width including a separated 2.4 m wide pedestrian path and 2.4 m wide bike path.

2.3.2 GRADES

Gentle grades will help achieve a path accessible to all users and will help minimise bike speeds.

Austroads Part 6A recommends:

- A "desirable maximum" gradient of 3%
- A maximum gradient of 5%, with short flatter sections providing relief at regular intervals
- Gradients steeper than 5% only where unavoidable
- Avoid combining steep grades with sharp horizontal curvature

In addition, AS 1428.1:2009 specifies that:

- Where the gradient is 1:33 (3%), level rest areas 1.2 m long should be provided at not greater than 25 m intervals, whereas at 1:20 (5)% the interval should not exceed 15 m. Between gradients of 1:33 and 1:20 the interval should be interpolated. Landings are not required on gradients less than 1:33. Paths with a gradient steeper than 1:20 are to be considered as ramps for design purposes.
- Hand rails are required for gradients steeper than 5%
- Where the gradient is 1:14 (7%) the distance between landings should not exceed 9 m
- The intervals between landings may be increased by 30% where a wall, kerb and handrail, or kerb rail and handrail is provided on one side of the walkway (AS 1428.1: 2009 Clause 10.2 (b))

Note that Austroads Part 6A suggests that landings will affect cyclist comfort and convenience if used for more than a short length. This guideline recommends that if the ramp is greater than 200 m long, standard landings could present an inconvenience or hazard for cyclists, particularly travelling downhill. Therefore long steep ramps should preferably be avoided.

The intent of the concept design is:

- In general, a maximum grade of 5%
- In short sections, where 5% is difficult to achieve, a grade of up to 6% has been proposed (with handrails)
- Provide landings compliant with AS 1428.1:2009

2.3.3 CURVES

Austroads Part 6A recommends curve radii in relation to design speeds. For a design speed of 20 km/hr (generally recommended along the main GreenWay path, see above), the minimum curve radius should be 10 m.

Note that Austroads Part 6A recommends that the radius of a curve could be slightly less if the curve is designed with superelevation, however AS 1428.1:2009 specifies a maximum crossfall of 2.5%, which provides no reduction in the recommended 10 m minimum radius.

2.3.4 CLEARANCE, BATTERS AND BARRIERS

Austroads Part 6A provides a sketch illustrating recommended clearances for a bike path, reproduced in Figure 1.

Austroads Part 6A also recommends:

- Where there are hazards beside the path that could cause serious injury to cyclists (e.g. sharp surfaces), assess the risk of cyclists losing control and consider either increased clearance or shielding the hazard. A rub rail or cyclist friendly fence could be provided.
- Pedestrians also require a 2.5 m vertical clearance, including above stairs or ramps unless significant constraints exist.

Barriers/fences beside the path are recommended by Austroads Part 6A where:

- There is a steep batter or significant drop in close proximity to the path
- The path is adjacent to an arterial road and it is necessary to restrict cyclist access onto the road
- The path passes over a bridge or culvert
- A hazard exists adjacent to a particular bicycle facility
- To prevent cyclists taking unsafe or undesirable short-cuts
- Where the path geometry presents a risk to running off the path – e.g. a steep downhill grade

followed by a sharp turn

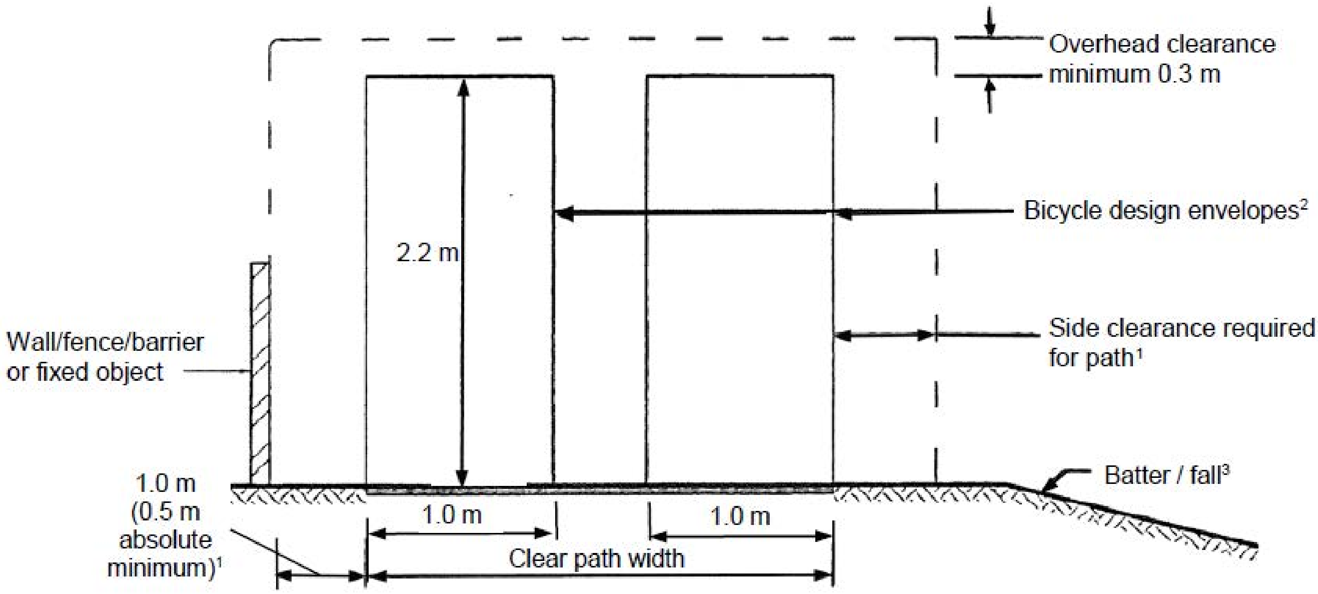
Austroads Part 6A provides detailed recommendations on where barriers should be provided and what type of barrier is appropriate. Figure 2 shows the key recommendations from this guideline.

Note that the recommendations refer to partial and full barrier fences. Austroads Part 6B provides some examples of partial and full barriers, suggesting that both are typically 1.2 m high, but a full barrier includes densely spaced railings/mesh while a partial barrier is largely open.

In terms of fencing types and styles, Austroads Part 6A recommends that:

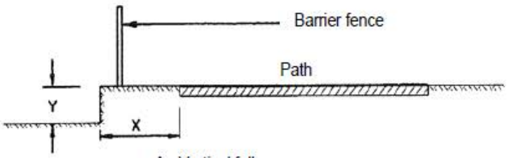
- The minimum height of a fence should be 1.2 m, suggested where hazards are "low"
- Where hazards are "severe", a fence of 1.4 m or higher should be considered
- In the design of barriers, consider the risk of handlebars or pedals getting caught in the structure. Deflection rails ("rub rails") and/or infill panels can minimise this risk
- For situations where a fence is not required, but there is a reason to provide a basic barrier, dense vegetation may be appropriate

Austroads Part 6A provides little guidance on defining hazards as low or severe. It is worth noting that Australian Standards for bridges (AS 5100:2017) require a 1.4 m barrier for a bridge used by cyclists. If the hazard presents a similar risk to a bridge, then a 1.4 m barrier is likely to be appropriate.



1 *This may be reduced to 0.3 m where a fence or obstacle has smooth features.*
2 *Refer to Section 3.2.2 for guidance on bicycle design envelopes.*
3 *Refer to Section 5.5.3 for guidance on batters and need for a fence.*

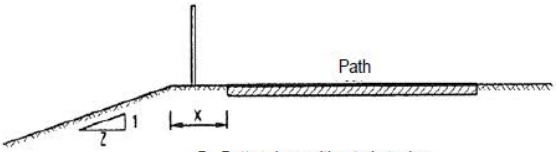
Figure 1: Clearance recommendations in Austroads Part 6A (2017, page 35)



A. Vertical fall

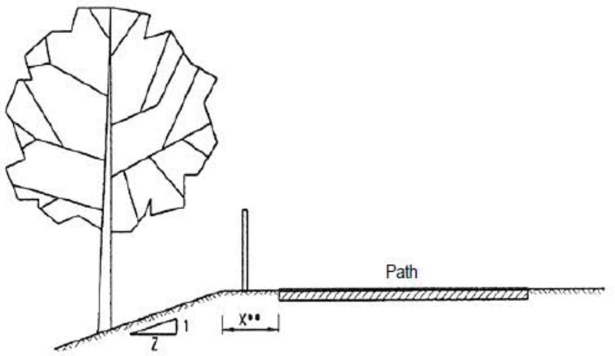
	X (m)	Y (m)
Fence not required*	<2	<0.25
Partial barrier fence required	<5	0.25 to 2
Full barrier fence required	<5	>2

* Batter off the surface where fall is within 1 m of path.



B. Batter slope without obstacles

	X (m)	Z (m)
Fence not required	<1 1 to 5	>8 >3
Partial barrier fence required	<5	1 to 3
Full barrier fence required	<5	<1



C. Batter slope with obstacles

	X (m)	Z (m)
Fence not required	<1 1 to 5	>8 >4
Partial barrier fence required	<5	3 to 4
Full barrier fence required	<5	<3

** Barrier fence required if obstacle within 1 m of path.

Figure 2: Recommendations on barrier fences next to batter slopes and vertical drops Austroads Part 6A (2017, page 40)

2.3.5 CROSSFALL AND DRAINAGE

Crossfall is desirable to facilitate drainage, however AS 1428.1:2009 specifies that any crossfall should not exceed 1:40 (2.5%). A flatter crossfall may be adopted provided that drainage is facilitated to avoid any ponding of water within the path.

2.3.6 SIGHT DISTANCE

Sight distance is important to reduce conflict and reduce the risk of accidents on shared paths, particularly at intersections, structures and changes in grade or direction.

Austroads Part 6A provides a formula for bicycle stopping sight distance, based on bicycle speed, path grade and friction. For a speed of 20 km/hr, and friction coefficient of 0.16 (typical for a bicycle in wet conditions) the stopping sight distance is calculated as:

- 21.8 m for a 5% uphill grade
- 28.6 m for a 5% downhill grade

Sight distance should be considered in the design of intersections, tunnels, curves, ramps, as well as planning new planting along paths.

The stopping distance is strongly influenced by speed, therefore if bicycle speeds can be reduced ahead of potential conflict points, then the need for long sight distances could be reduced. E.g. at 10 km/hr, the stopping sight distance becomes approx. 9-11 m for grades between 5% uphill to 5% downhill.

2.3.7 CPTED

Crime Prevention Through Environmental Design (CPTED) is a key consideration for the GreenWay. Important CPTED principles revolve around:

- **Surveillance** – passive surveillance or “eyes on the place”
- **Legibility** – being read and understood, allowing people to know where they are and how to get to where they are going
- **Territoriality** – a sense of clarity in the distinction between private and public space
- **Ownership of the outcomes** – a sense of ownership of the public realm, and other parts of the built environment, by the community
- **Management** – places that are well maintained will retain their CPTED qualities
- **Vulnerability** – some people and places are inherently more vulnerable, however vulnerability also increases in places which are isolated, or where there are hidden places.

The Queensland Government Crime Prevention Through Environmental Design Guidelines (2007) include some good design guidelines for pedestrian and cycle paths. Nine design actions are recommended:

1. Adopt neighbourhood and centre urban design layouts which do not separate

pedestrian/ cyclist routes from the street network

2. Design, develop and manage footpaths and cyclist paths of sufficient width and quality to meet likely needs
3. Within the cyclist/pedestrian realm, and especially separated systems, avoid entrapment spots like, long tubes or corridors, blind corners, tight spaces, and underpasses where, for example, the whole route cannot be seen from within or before entering by the pedestrian or from without by the observer
4. Manage intersections between pedestrians/cyclists and vehicle traffic at grade, without resorting to underpasses/overpasses except where supported by both the urban topography and active edges of adjoining/defining buildings and uses
5. Acknowledge the detailed design requirements for physical safety (and therefore potentially security) that arise from the different design speeds of pedestrians and cyclists.
6. Design independent pedestrian/cyclist systems with as much connectivity and surveillance (both actual and perceived) as is consistent with the overall context (for example, avoiding hiding them behind high fences, sound barriers, major engineering structures, blank-façade buildings and the like) and introducing activity places and other points of urban contact along the route.
7. Avoid creating narrow pedestrian/cyclist paths hidden from view behind side or rear fencing or buildings.
8. Use landscaping and built features, including signage and artwork, to enhance legibility.
9. Where the principles of CPTED cannot be sufficiently applied, be prepared to support separate pedestrian/cyclist systems with organised technological and human surveillance or special management regimes (for example, after hours).

The first few points were more relevant at the Master Plan stage, however the concept design can still aim to minimise entrapment spots, blind corners and tight spaces, and can aim to maximise sight lines. The concept design can also integrate connectivity and surveillance, activation and features to manage bicycle speeds.

The nature of the existing and proposed GreenWay path is however that there are likely to be places where the final point becomes relevant. Particular areas of concern include:

- Each of the proposed tunnels
- The proposed elevated path between Constitution Road and Hercules Street
- Anywhere that the path is located off-road

As CPTED considerations can inform planning and design decisions throughout the process, the whole concept design scope has been assessed against the principles above. Design responses should be given further consideration in the detailed design stage.

Table 1: Preliminary CPTED evaluation

Section of the GreenWay	CPTED risks	Potential mitigating measures*
Bay Run upgrade between UTS Rowing Club and Lilyfield Road bridge	Most of the path is visible from the City West Link road, but there is a short section along the Bay which cannot easily be seen from the road	Existing mural improves sense of safety Consider sight lines into this space from other sections of the path
Lilyfield Road bridge	Minimal passive surveillance from surroundings	Activation Maintain clear sightlines
Under Lilyfield Road bridge and City West Link	Hidden places, entrapment spots Poor passive surveillance	Public art, activation
Richard Murden Reserve	Sections of path are hidden from the road. Vegetation affects sight lines to the road and within the park. Some structures in the park potentially create hidden places	Consider placement of vegetation and built structures in relation to the path
Gadigal Reserve	Proposed works will improve access and enable better pedestrian movement and passive surveillance throughout the reserve, although some zones will still remain somewhat isolated, and there is limited visibility into the reserve from surrounding streets and buildings.	Design to provide sight lines along the main shared path and from the shared path into other parts of the reserve, including the informal shared path on the western side of the channel and the nature observation area under the rail overpass.

Section of the GreenWay	CPTED risks	Potential mitigating measures*
Longport Street tunnel	Sightlines Hidden places, entrapment spots Extended section of path isolated from surroundings either side of the tunnel	Consider sightlines through tunnel, as well as to/from each tunnel entrance. Avoid creating hidden places either side of tunnel. Design of tunnel portals Public art
Lewisham West – path from Old Canterbury Road to Longport Street, on western side of light rail	Much of the main path is separated from surrounding development by a vegetated buffer and a level difference, which will limit passive surveillance from surrounding buildings.	Design to provide sight lines along the main shared path and between the shared path, the light rail stop and the dog off leash area. Consider options to activate the small strip of open space along the path (e.g. with rest areas, interpretation of heritage features, public art).
Lewisham West – dog off leash area	Level differences reduce passive surveillance from surrounding development, and the space is not visible from the street.	Consider sightlines and passive surveillance within the site and from adjacent buildings and light rail. Consider lighting.
Weston Street	Similar to any existing street	GreenWay traffic will potentially increase eyes on the street
Davis Street tunnel	Sightlines Hidden places, entrapment spots	Consider sightlines through tunnel, as well as from Waratah Mills light rail stop and from Waratah Mills apartments Avoid creating hidden places either side of tunnel Design of tunnel portals Public art
Path from Davis Street tunnel to Johnson Park	Narrow space without active frontage Potential for vegetation, fences, etc to obscure sightlines from Waratah Mills apartments	Balance residents' privacy with passive surveillance of path Consider sightlines from light rail, to/from Johnson Park
Path through Johnson Park	Existing and proposed dense vegetation close to path could create hidden places	Johnson Park is already relatively active and well connected Consider structure of vegetation adjacent to path (low vegetation near path, higher set back)
Constitution Road tunnel	Sightlines Hidden places, entrapment spots Poor passive surveillance, particularly from southern side (but the southern end of Johnson Park is also currently a relatively inactive spot) Northern tunnel entrance will be low and will allow limited surveillance from either Constitution Road or from Arlington light rail stop	Consider sightlines through tunnel Activation of this part of Johnson Park (e.g. idea to place exercise equipment here) Design of tunnel approach from Johnson Park Design of tunnel portals Public art
Elevated path from Constitution Road to Hercules Street	Long isolated stretch with no escape routes, and poor passive surveillance – views from neighbouring residences are likely to be patchy, as there is relatively dense vegetation in the rail corridor, a noise wall along the northern part of the western side, and residences are located at a much higher elevation than the proposed path.	Consider sightlines from residences more carefully at detailed design stage. Also consider sightlines from light rail. Consider how vegetation removal will alter sightlines when the path is constructed. If passive surveillance is indeed lacking, consider supporting measures (e.g. CCTV)
Hercules Street open space	Narrow space without active frontage Most of the existing houses are set back a long way from the open space Existing mounds reduce sightlines from light rail	Consider sightlines from Hercules Street and Jack Shanahan Park Consider placement of vegetation in relation to the path Consider potential for future development to activate western frontage
Roadside path along Hercules St, Terrace Road and across Ewart Street	Hercules Street only has houses on the opposite side Terrace Road has no active frontages Underpasses are tight spaces with potential hiding spots behind structures	Consider options to design out hidden places and improve amenity at underpasses GreenWay traffic will potentially increase eyes on the street
Ness Avenue and Garnet Street bike boulevard	Similar to any existing street	GreenWay traffic will potentially increase eyes on the street

Section of the GreenWay	CPTED risks	Potential mitigating measures*
Path through edge of Golf Course	The Golf Course is dark at night, but is relatively open without hidden places	Maintain sightlines from Tennent Parade

* Lighting is a potential mitigating measure throughout the GreenWay, therefore is not listed next to each individual place. Refer to lighting report (Appendix C)

2.4 OTHER DESIGN CONSIDERATIONS

2.4.1 LEVELS

For various reasons, where the GreenWay path is proposed at-grade, the preferred option is to build the path above existing ground levels (and incorporate cross-drainage as required):

- Soil contamination: throughout the GreenWay corridor, soil contamination is likely to be an issue. Therefore excavation and spoil disposal should be minimised
- Trees: where the path passes close to existing trees, excavation should also be avoided to minimise impacts on existing root systems
- Within Richard Murden Reserve, periodic tidal inundation of the park is another reason to elevate the path above existing ground levels

2.4.2 BARRIERS

Along the main GreenWay path, the intention is to minimise the use of barriers, but they will be required in some areas to provide for the safety of all users. A risk assessment including hazard rating should be completed at the detailed design stage, however at this stage it is expected that within the concept design scope, the places where the hazard may be assessed as severe are:

- The ramp linking Hercules Street to the open space south of the street – particularly at the upper end and on the outside of the bend
- The elevated path between Hercules Street and Constitution Road, where there will be a steep drop from the path, several metres down into the light rail corridor
- If/when the path is constructed on a deck extending over Hawthorne Canal
- If Lilyfield Road bridge is rearranged so that bikes use the space immediately next to the barrier on either side of the bridge
- Tight curve linking the GreenWay path to the Bay Run at the western end of Lilyfied Road bridge

Elsewhere within the concept design scope, the preference, where barriers are needed at all, is for a lower (1.2 m) barrier, which will provide better amenity for pedestrians.

2.5 TYPICAL DETAILS AND EXAMPLES

Council has provided some typical path sections incorporating the basic elements to incorporate into the path design. These are reproduced in Figure 3 to Figure 5. These sections have provided a starting point on which to base the path design:

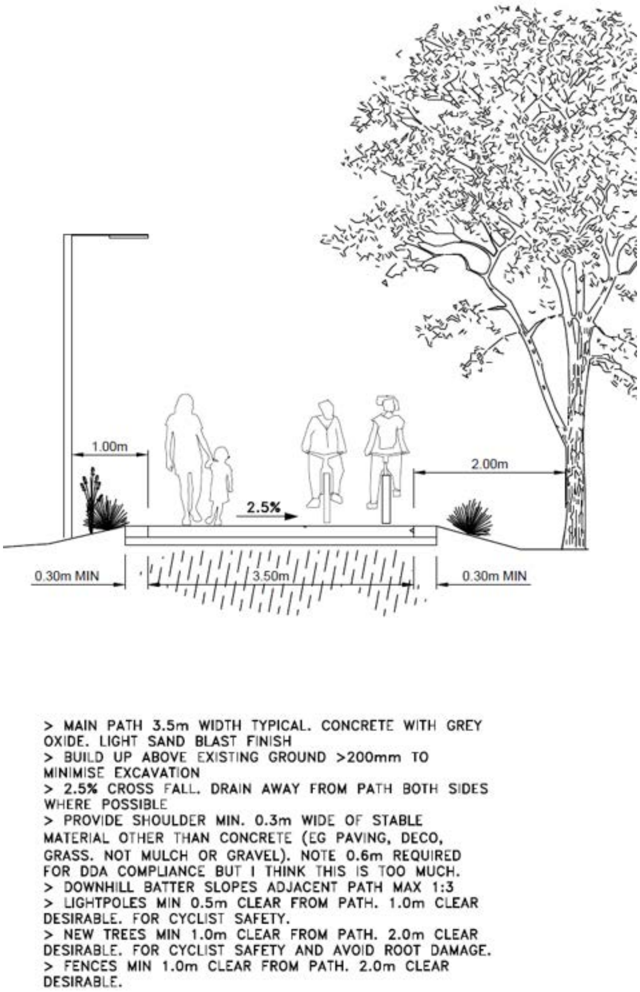
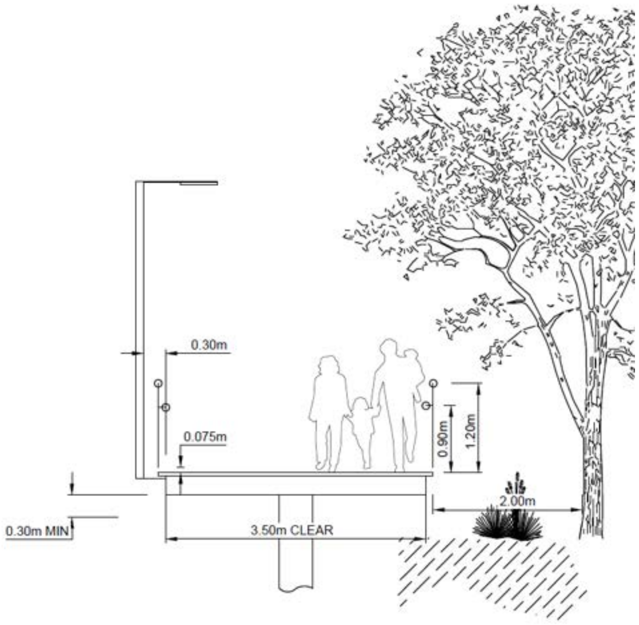
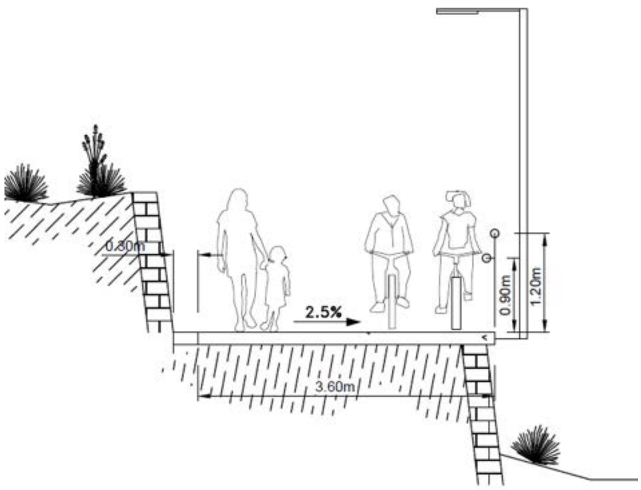


Figure 3: Typical section, on-grade path (Inner West Council 2018)



> MAIN PATH 3.5m CLEAR WIDTH TYPICAL. FRP MINIMESH DECK
> ONLY USE ELEVATED PATH WHERE 0.6m ABOVE GROUND. RAMP UP WITH EARTH RAMP TO ENSURE 0.3m FROM UNDERSIDE OF STRUCTURE TO FFL.
> 0% CROSS FALL
> PROVIDE BALUSTRADES BOTH SIDES. MIN HEIGHT 1.2m.
> PROVIDE HANDRAILS BOTH SIDES WHEN GRADE >5.0%. HAND RAIL HEIGHT 0.9m
> PROVIDE KERB RAIL OF BALUSTRADE 75mm ABOVE DECK
> LIGHTPOLES MIN 0.3m CLEAR FROM PATH FOR CYCLIST SAFETY. MOUNT OFF PATH STRUCTURE TYPICAL TO AVOID TRENCHING IMPACT ON ADJACENT TREES
> NEW TREES MIN 2.0m CLEAR FROM PATH. FOR CYCLIST SAFETY AND AVOID PATH DAMAGE.

Figure 4: Typical section, elevated path (Inner West Council 2018)



> GENERALLY AS PER ON-GRADE PATH
> 2.5% CROSS FALL. DRAIN AWAY FROM PATH BOTH SIDES WHERE POSSIBLE
> PROVIDE 0.3m WIDENING ADJACENT RETAINING WALLS
> DOWNHILL BATTER SLOPES ADJACENT PATH MAX 1:3 ELSE PROVIDE BALUSTRADE
> TRY TO KEEP RETAINING WALLS LESS THAN 1.8m HIGH

Figure 5: Typical section, path adjacent to wall or steep batter (Inner West Council 2018)

3 ON-ROAD LINKS

The GreenWay includes several sections that will need to be built within road reserves. At Ness Avenue and Weston Street, it is recommended that these roads be converted to bike boulevards, while in other locations separate paths are proposed alongside the road

3.1 LOCATIONS

The Master Plan establishes the route alignment and identifies where the main GreenWay links will have to be on road. The Master Plan also identifies which sections should be designed as bike boulevards and which should be separate paths within the road reserve. The concept design proposes the following:

- Ness Avenue bike boulevard (full length of Ness Avenue and lower section of Garnet Street)
- Terrace Road-Hercules Street roadside shared path (from Ewart Street intersection to light rail corridor entrance near #101 Hercules Street)
- Weston Street bike boulevard (from Waratah Mills light rail stop to Old Canterbury Road)

3.2 DESIGN PRINCIPLES

In selecting appropriate design options for these on-road links, the following principles have prevailed:

- The intention of the GreenWay is a pedestrian and bike route that is accessible to all users, including bike riders from age eight to eighty
- On-road sections need to be safe for all users
- In designing GreenWay streets, prioritise the most vulnerable road users – pedestrians and bikes
- In residential streets, minimise the impacts on residents, particularly impacts on parking, privacy, safety, visual amenity

Bike boulevards are a novel option in an Australian context, but have been proposed for the GreenWay due to the regional significance of the route, and the fact they are in keeping with the principles of the GreenWay:

- Bike boulevards provide clear priority to bikes in the streetscape, and make bike traffic more visible and prominent
- By reducing vehicle speeds, bike boulevards also have the potential to provide better pedestrian safety and amenity, making road crossings easier and safer
- Because traffic lanes are shared by bikes and vehicles, there is potentially more space for greening the streetscape
- Creating bike boulevards will clearly identify GreenWay streets as distinct from other local roads, facilitating wayfinding
- Bike boulevards are potentially a template for the trellis of green streets envisaged in the GreenWay Master Plan

The GreenWay is considered a good opportunity to conduct a full-scale trial of bike boulevard treatments, because it has been identified as the number one priority Green Grid project in the Eastern Sydney District Plan. It has the potential to lead the way and set a new standard for green, pedestrian- and bike-friendly streets. It will attract significant bike numbers, and will be monitored and evaluated.

Bike boulevards have been recommended specifically for Ness Avenue, Garnet Street and Weston Street because:

- Traffic volumes in these streets are already low and can be reduced further by works to discourage through traffic
- Vehicle speeds in these streets are already low and can be reduced further by traffic calming measures
- Works to discourage through traffic and calm vehicle speeds provide outcomes with multiple benefits, and have the in-principle support of local

residents

- When compared with separated cycleways, bike boulevards can be constructed with minimal impact on parking
- By putting bikes in the centre of the road where they are more visible, bike boulevards minimise the risk of various common conflict points associated with separated cycleways or roadside shared paths:
    - Bike-vehicle conflict at driveways
    - Car door zone incidents adjacent to parked cars
    - Bike-pedestrian conflict
- Bike boulevards can be constructed more cost-effectively than separated cycleways, with less impact on existing infrastructure or trees

Bike boulevards have not been proposed for the section along Terrace Road and the lower end of Hercules Street, as these streets have higher vehicle numbers, which cannot easily be reduced. Furthermore, the section of Terrace Road in question has no private properties and no on-street parking, and the section of Hercules Street in question has private properties only on one side of the street, therefore a roadside shared path can be built here with less impact on residents and fewer potential points of conflict.

3.3 GUIDELINES, STANDARDS AND EXAMPLES

3.3.1 BIKE BOULEVARDS

Bike boulevards are common in the Netherlands (where they are known as "fietsstraats") and have also been implemented elsewhere in the world, for example as "cycle streets" in the UK.

Two bike boulevards have been constructed recently in Perth, where several more are planned. The two completed so far are:

- Shakespeare Steet bike boulevard, City of Vincent
- Bayswater to Morley bike boulevard, Bayswater (Stage 1 has been completed along Leake Street and May Street, from the Swan River foreshore to Adelphi Street). Leake Street is shown in Figure 6

Figure 6: Bayswater to Morley bike boulevard at Leake Street

Bike boulevards are designed for mixed bike and vehicle traffic, but give clear priority to bikes. Typical features include:

- A speed limit of 30 km/hr
- Physical traffic calming features to promote self-enforcement of the 30 km/hr speed limit
- A distinctive road surface to clearly indicate that this is a different type of street
- Entry treatments also help alert people that they are entering a special low-speed, bike friendly street

As bike boulevards are relatively new in Australia, there are not yet any local design guidelines which specifically cover bike boulevards. However relevant international guidelines and local examples are discussed below.

Speed limits

There is an increasing movement to promote 30 km/hr speed limits, including Victoria's "Thanks for 30" initiative. As part of this initiative, Yarra City Council is currently trialling 30 km/hr speed limits in the northern parts of Fitzroy and Collingwood. The Thanks for 30 campaign (thanksfor30.com.au) cites evidence that 30 km/hr speed limits improve safety for pedestrians and other vulnerable road users, and has a minimal impact on travel time.

An Austroads Research Report "Cycling on Higher Speed Roads" (2012) presents the curve shown in Figure 7, which relates pedestrian fatalities to vehicle speeds. This is based on data from several different studies including Australian and international studies. It shows that:

- At **50 km/hr** (a typical speed limit on NSW residential streets), the probability of a fatality in a pedestrian-motor vehicle accident is around **50%**
- At **40 km/hr**, this probability drops to around **20%**
- At **30 km/hr**, it drops to around **5%**

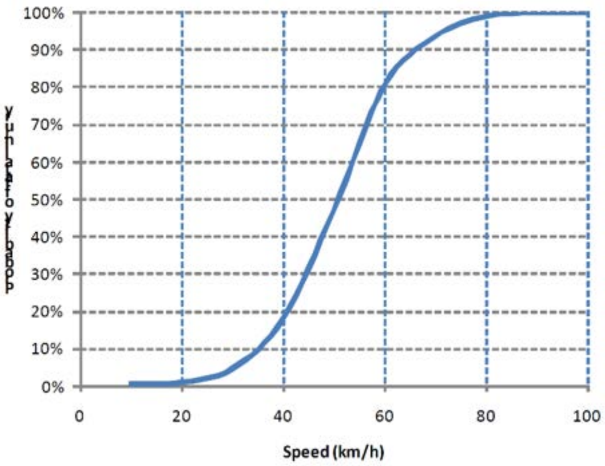


Figure 7: Probability of pedestrian fatality by motor vehicle speed

The traffic engineering report (Appendix A) provides more information on 30 km/hr speed limits in the Australian and NSW context.

Traffic volumes

In the Netherlands, the CROW "Design Manual for Bicycle Traffic" (2016 edition) establishes the following principles for design of "bicycle streets":

- Minimising hindrance due to parked vehicles
- Using smooth surfacing, preferably asphalt
- Creating traffic islands at points where choices need to be made
- Changing right-of-way rules at intersections, to give bicycle streets priority
- Suppressing (motorised) through traffic

The CROW manual (2016) also recommends that for a bike boulevard to function appropriately:

- Bicycle traffic should be genuinely dominant in the street scene, e.g. there should be more bikes than motorised vehicles using the street.
- A high absolute number of bikes should be using the street – a threshold of 1,000 cyclists per day is suggested
- A low volume of vehicle traffic is preferable. 500 vehicles per day is suggested as a guide, however up to 2,500 vehicles per day is stated as a maximum, providing that the number of bicycles exceeds this.

Note that streets designated as "Fietsstraats" have 30 km/hr speed limits.

Expected bike numbers on the GreenWay were estimated in the Master Plan as shown in Table 2.

Table 2: Estimated bike and pedestrian numbers from the GreenWay Master Plan

Year	Bike numbers		Pedestrian numbers	
	Per day	Peak hr	Per day	Peak hr
2021	300-450	45	300-450	45
2031	600-900	90	600-900	90
2041	1200-1800	180	1200-1800	160

In Western Australia, the approach has been to implement bike boulevards on streets with less than 1,500 vehicles per day. This is perhaps a more realistic approach in an Australian context. In New Zealand, Auckland's bike boulevards policy aims for vehicle numbers under 1,000 vehicles per day, with a maximum of 2,000 vehicles per day.

Traffic volumes (existing and expected future) on Weston Street, Ness Avenue and Garnet Street are discussed below.

3.3.2 ROADSIDE SHARED PATHS

The shared path guidelines described in Section 2 also apply to roadside shared paths. In addition, the following considerations apply:

- In some cases, to create the shared path, it is proposed to narrow the roadway. Where this is proposed, the concept design proposes minimum widths of 2.1 m parking and 2.8 m traffic lanes
- Wider lanes are proposed on Terrace Road to accommodate vehicle movements around bends under the rail bridges
- Shared paths are proposed at footpath level, so there is a level difference from the road
- Where possible, a vegetated buffer is proposed between the shared path and the road
- Where there is no space for a vegetated buffer, consider a barrier to the road (pedestrian fence to RMS standards)
- Where the path is constrained on either side (e.g. by fences, retaining walls, other structures), consider whether the path can be widened or the structures relocated to set them back from the path

3.3.3 SHARED ZONES

Shared zones are proposed at the following locations:

- Northern part of Canal Road between Lilyfield Road and boat ramp
- At the northern end of Weston Street (to access existing service road)

Shared zone design should consider RMS' Technical Direction TTD 2016/001 "Design and implementation of shared zones including provision for parking".

3.3.4 INTERSECTION TREATMENTS

Where the GreenWay is on-road and passes through intersections, these intersections will be modified to improve pedestrian and bike safety. At each location where a street meets a bike boulevard, a threshold treatment is proposed to slow traffic and signal the entry to a different traffic environment.

Where vehicle numbers are low enough, the preferred treatment at intersections is continuous footpaths, as these favour pedestrian traffic as well as slowing vehicles. An example is shown in Figure 8. A typical layout is shown in Figure 9.

NSW RMS guidance on continuous footpath treatments (Technical Direction TDT 2013/05, "Continuous Footpath Treatments", August 2013) recommends that they are appropriate where:

- Typically no more than 45 vehicles per hour moving through the intersection (measured for three periods of one hour in any day, capturing the busiest traffic flows that occur at that location)
- Few, if any heavy vehicles frequenting the intersection
- Any number of pedestrians uses the intersection
- The design should minimise risks to pedestrian safety. It is recommended that the effective speed of vehicles once the treatment is implemented should be 10 km/hr or less

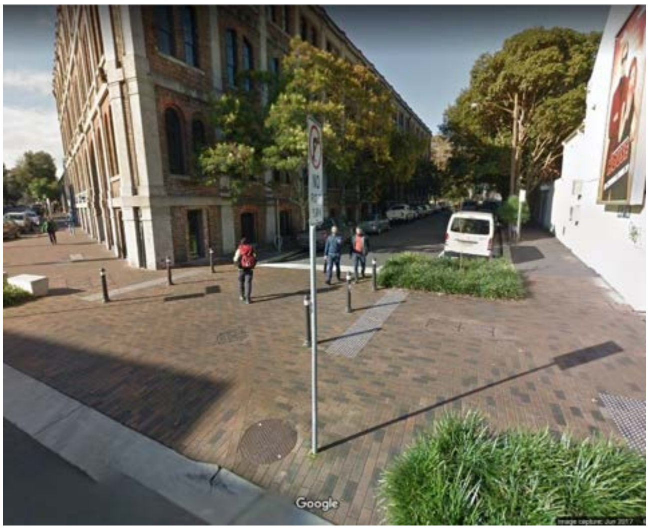


Figure 8: Continuous footpath example at intersection of Ivy Street with Abercrombie Street in Darlington NSW

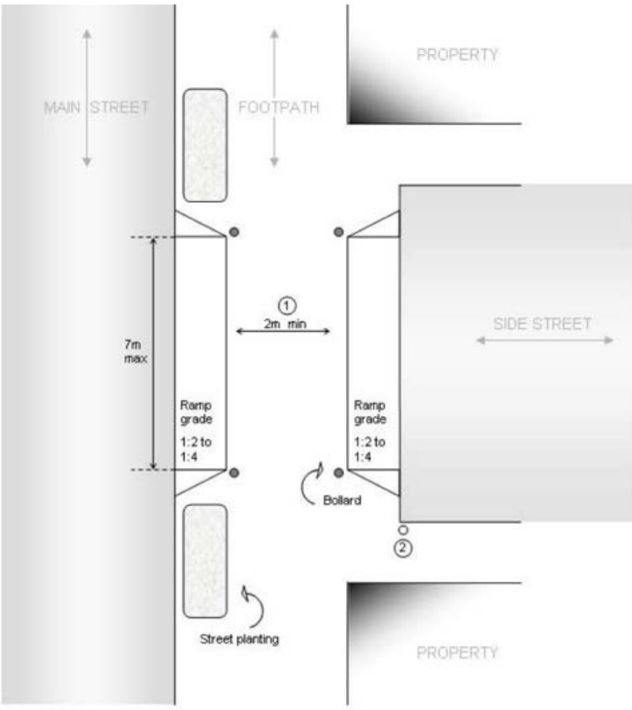


Figure 9: Typical layout of continuous footpath treatment (NSW RMS 2013)

Where vehicle numbers are too high for continuous footpaths, other threshold treatments are recommended, including:

- Speed humps to slow vehicle speeds on approach
- Kerb blisters to prevent parking too close to corners, improve visibility at intersections and reduce pedestrian crossing distances
- It is also proposed that key intersections be rearranged to give GreenWay traffic priority, while traffic joining the bike boulevard would stop or give way. This is discussed further below.

3.4 LOCAL DESIGN CONSIDERATIONS & RECOMMENDATIONS

3.4.1 WESTON STREET

Weston Street currently has low traffic numbers. 2014 AADT was measured at 80 vehicles per day northbound and 160 vehicles per day southbound (total 240) between Windsor Road and Channel Street (ref Jacobs traffic report 2018, Appendix D of Master Plan). Vehicle numbers are expected to be similar between Channel Street and Old Canterbury Road. In 2014, the 85th percentile speed was 46.8 km/hr.

Surveys undertaken in 2017 in Weston Street at Old Canterbury Road show that peak hour traffic volumes are less than 45 vehicles per hour (ref Jacobs Bike Boulevards report 2018 – Appendix A).

The proposed closure of Weston Street at Old Canterbury Road will ensure that vehicle numbers remain low on Weston Street. It could even lead to a small reduction in vehicle numbers, particularly between Channel Street and Old Canterbury Road.

Weston Street traffic therefore falls within the range recommended for bike boulevards in various guidelines. Bike numbers are likely to exceed vehicle numbers by 2021 and vehicle numbers are likely to remain low.

However current 85th percentile vehicle speeds are significantly higher than 30 km/hr. The street should be designed so that the proposed speed limit is self-enforcing. Therefore traffic calming measures are proposed to reduce vehicle speeds.

Along Weston Street, and at each of its intersections, continuous footpath treatments are recommended as an appropriate treatment.

At the southern end of Weston Street, near the entrance to the Waratah Mills light rail stop, a priority change is recommended at the intersection between Weston Street and Weston Street, so that bike boulevard traffic has priority and the connecting leg of Weston Street has to give way. Traffic speeds are expected to be slow at this intersection, however the change in priority is still recommended for the following reasons:

- To give GreenWay traffic priority
- To avoid putting cyclists into the situation (typically very uncomfortable for less confident riders) where they must wait in an intersection to turn right, while cars may approach behind them and pass them on the left
- Once the bike boulevards are resurfaced with coloured and stamped asphalt in the future, the change in surface type could otherwise lead to some confusion about who gives way to who

In addition, the following measures are proposed within Weston Street itself to calm traffic and maintain vehicle speeds below 30 km/hr:

- Kerb blisters at intersections
- A raised platform is proposed at the bend, to particularly slow vehicle speeds here, where the road width also changes
- In the wider section of Weston Street (from the bend to Old Canterbury Road), a central median is recommended to reduce vehicle lane widths
- In the narrower section of Weston Street (south of the bend) a speed hump is only recommended if vehicle speeds prove to be a problem in the future, after other works have been constructed

Otherwise, measures in Weston Street have been designed to accommodate vehicle turning movements (including access to driveways), minimise parking loss and maintain amenity for residents.

3.4.2 NESS AVE AND GARNET STREET

Current traffic volumes on Ness Avenue and Garnet Street are higher than Weston Street, however the proposed partial closure of Riverside Crescent (to prevent left turn in from Wardell Road) will reduce numbers.

Daily traffic volumes measured on Ness Avenue (between Garnet St and Tennyson Street) in 2007 were just under 1,000 vehicles per day. The 85th percentile speed was 51.8 km/hr.

Jacobs' Bike Boulevards Report (Appendix A) shows that currently in the morning peak hour, 292 vehicles turn from Wardell Road left into Riverside Crescent (94 in the evening peak hour). Many of these vehicles would continue up Riverside Crescent to Ewart Street, however it has also been shown that some turn onto Tennyson Street then Ness Avenue, to access Garnet Street.

Jacobs reports that the two -way traffic volumes of Ness Avenue on an average weekday are 105 vehicles per hour in the morning peak and 107 per hour in the evening peak. Traffic surveys in June 2018 assessed the number of vehicles turning from Riverside Crescent onto Tennyson Street and Ness Avenue. Numbers are shown in Figure 10. Jacobs recommends that the left turn ban could reduce the number of vehicles on Ness Avenue by around 20 to 30 in the morning peak hour. This would bring the morning peak hour numbers below 100. In the evening peak hour, any changes would be less significant.

Traffic volumes on Ness Avenue therefore fall generally within the range recommended for bike boulevards in the Australian and New Zealand context. The left turn ban from Riverside Crescent will help reduce vehicle numbers in the morning peak, and help maintain vehicle numbers below 1,000 per day. However bike traffic is unlikely to exceed this figure for many years.

Current 85th percentile vehicle speeds on Ness Avenue are significantly higher than 30 km/hr. The street should be designed so that the proposed speed limit is self-enforcing. Therefore traffic calming measures are proposed to reduce vehicle speeds, including:

- Raised flat topped speed humps at each entry to the bike boulevard (including Balfour Street, Tennyson Street and Garnet Street)

- Kerb blisters at intersections
- Where Tennent Pde meets Garnet Street, a stop sign is also proposed to clarify which traffic has priority at this intersection.

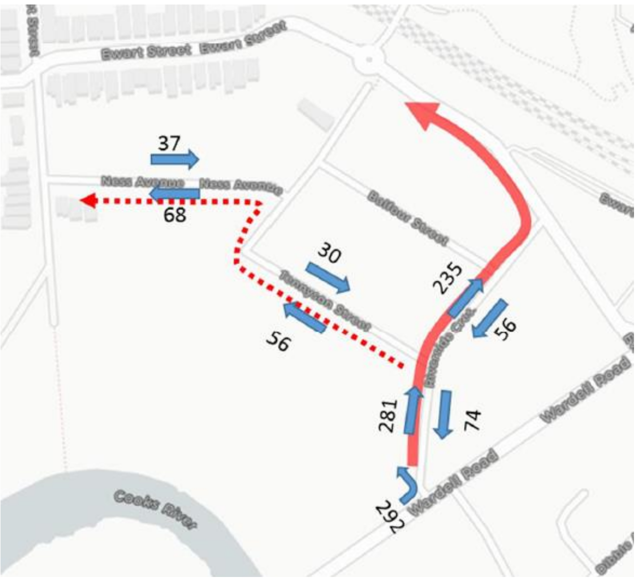


Figure 10: Traffic volumes, morning peak hour

Note that conversion of the existing mid-block slow point on Ness Avenue to a raised flat-topped speed hump was considered, as single-lane slow points can lead to conflict between vehicles and bicycles, but this change was not recommended due to lack of resident support and likely minor impact on vehicle speeds.

Along the Ness Avenue bike boulevard, there are two intersections where it is recommended that the priority be rearranged so that bike boulevard traffic has priority and the connecting street has to stop or give way. This is recommended at Ness Ave/Garnet Street (stop) and Ness Ave/Tennyson Street (give way). The reasons for these priority changes are the same as those flagged at Weston Street above, but in addition:

- Reducing traffic speeds is more important here (particularly at Garnet Street for vehicles coming downhill)
- Asking less confident riders to stop, wait for passing traffic and start moving again in the Garnet Street intersection would be particularly uncomfortable, as it is a steep hill and there is more traffic on Garnet Street than on Weston Street

For this to work at each intersection, changes are proposed to the intersection geometry as well as signage and line marking. The geometry will be changed so that the Give Way approach meets the intersection at a perpendicular angle. Similar precedents exist at Burren Street/Albert Street in Erskineville and at High Street/Smith Street in Chatswood. The latter example is pictured in Figure 11.

Note that at the Weston Street/Weston Street intersection (southern end of Weston Street) a similar situation exists, however a priority change has not been proposed here due to the generally low traffic volumes on Weston Street and expected very low volumes in the short dead end near Waratah Mills light rail stop.

Figure 11: High Street/Smith Street intersection in Chatswood

3.4.3 HERCULES ST AND TENNENT PDE

Important design considerations here include:

- Proximity to existing large trees along Hercules Street. The proposed path has been aligned to avoid the trees, however it is located within the root zone. A sensitive design is required to minimise impact on the trees. Options could include local adjustment to the path alignment, or potentially raising the path just off the ground.
- Under the "disused fork" it is proposed to build the path out into the roadway and narrow the traffic lanes. Vehicle movements can be accommodated within the narrower roadway, however local residents raised vehicle speeds as a concern here, as the footpath is exposed to oncoming traffic, and residents cited incidents where vehicles have lost control in the bend and mounted the kerb onto the footpath. Therefore measures have been proposed here to slow vehicle speeds and protect the footpath from vehicles.
- Under the Sydenham to Bankstown Railway line, it is proposed to widen the path away from the road, cutting into the existing slope and building a retaining wall. This will require realignment of the rail corridor fenceline.
- At the entrance to the Jack Shanahan Reserve car park, a continuous footpath treatment is proposed.

4 OTHER TRAFFIC WORKS

Apart from the proposed bike boulevards and roadside paths, there are other important traffic works proposed at Riverside Crescent, Ewart Street, Hercules Street and Canal Road/Lilyfield Road

4.1 RIVERSIDE CRESCENT PARTIAL ROAD CLOSURE

A partial closure of Riverside Crescent is proposed at Wardell Road to prevent left turns from Wardell Road into Riverside Crescent, and reduce traffic volumes on the proposed Ness Avenue bike boulevard.

This has been assessed from a traffic perspective (including impact on the Wardell Road/Ewart Street intersection) and the assessment is included in Jacobs' Bike Boulevard Report (Appendix A). The key findings were:

- That there would only be a minor difference in intersection performance at the Wardell Road/Ewart Street intersection as a result of the additional traffic volumes.
- That the partial closure could be expected to reduce morning peak hour traffic numbers on Tennyson Street by 20-40 trips and on Ness Avenue by 20 to 30 trips

Note that two options were considered here – either to prevent all turns in from Wardell Road into Riverside Crescent, or to prevent only left turns in. The left turn ban is the important action to reduce traffic volumes. Relatively few vehicles turn right at any time of day (6 in AM peak hour; 9 in PM peak hour) therefore a right turn ban would have negligible impacts on traffic volumes.

Allowing vehicles to turn right from Wardell Road into Riverside Crescent will reduce the impact on residents by keeping this option open to them – it is likely to be mainly local residents who would use this option.

There is a small risk that the partial closure will leave enough space in the intersection for some vehicles to turn left anyway, ignoring the ban. It is difficult to police this behaviour.

4.2 EWART STREET CROSSING

At Ewart Street, the existing crossing is a pedestrian refuge. It is shown in Figure 12.

Figure 12: Existing Ewart Street crossing

An upgrade of this crossing has been proposed to improve safety and amenity for pedestrians and cyclists. The Master Plan proposed a signalised intersection here, however the intersection does not currently meet the warrants for signalisation.

Furthermore, during the Master Plan process, it was expected that the Sydenham to Bankstown active travel corridor would also pass through this intersection. With those plans currently shelved, it is less likely that an exception to the warrants might be approved here.

Alternative options have therefore been considered including:

- A shared pedestrian and bike zebra crossing adjacent to the existing roundabout (preferred)
- As above, however the roundabout replaced by a T-intersection
- An expanded pedestrian refuge large enough for bikes

An example of a shared pedestrian and bike zebra crossing is shown in Figure 13. Discussions with RMS indicated that this example at Westmead represents their preferred configuration. It features:

- Shared paths on either side
- A wide zebra crossing with part coloured green between the white stripes
- No additional road signage (other than that associated with a standard pedestrian crossing)

Figure 13: Example of a shared pedestrian and bike crossing at Hawkesbury Road, Westmead

A shared crossing would provide the best amenity for pedestrians and bikes, which is why it is the preferred option. Retaining the roundabout is also preferred to minimise costs and impacts on local traffic.

Discussions with RMS (and a previous attempt to install a pedestrian crossing at this location) suggested that the key issue with this option, adjacent to the existing roundabout, is sightlines. The most restricted sightline is that for vehicles approaching from Terrace Road and turning left into Ewart Street. Currently, the rail corridor fenceline restricts this view, as shown in Figure 14.

Figure 14: Current restricted sightline from Terrace Road to Ewart Street (east)

As part of the works proposed here, relocation of this fenceline is therefore recommended to improve sight lines.

4.3 HERCULES STREET CROSSING

At Hercules Street, there is an existing zebra crossing, shown in Figure 15.

Figure 15: Existing crossing at Hercules Street

This crossing is located in the only possible safe place along this section of Hercules Street, so its location needs to remain unchanged, however an upgrade is proposed to create a rideable crossing.

Currently neither this crossing, nor the footpaths either side, are rideable. It is proposed to install a rideable crossing here (similar to the Westmead example shown in Figure 13) and rideable links on either side.

Two main options were considered for the links on either side of the crossing:

- Shared paths (widening existing footpaths and converting to shared paths)
- Separated paths (bidirectional bike lanes either side of the roadway)

Shared paths are preferred for the following key reasons:

- It is more consistent with the rest of the GreenWay, including proposed shared paths immediately either side of Hercules Street
- Shared paths following the footpath alignment will allow bikes to approach the crossing at a more comfortable angle, where they are more likely to see and be seen by approaching traffic
- Shared paths take up less space than the combination of footpaths plus separated bike paths

4.4 CANAL ROAD/LILYFIELD ROAD

Where Canal Road meets Lilyfield Road, there is currently a large turning circle, shown in Figure 16.

Figure 16: Lilyfield Road/Canal Road intersection

This is a location with low vehicle numbers but high volumes of bike and pedestrian traffic. It is therefore proposed to reduce the scale of this intersection and convert Canal Road, from here to the boat ramp, to a shared zone.

In addition, it is proposed that beyond the main driveway of #91 Canal Road, the road should be accessible only to authorised vehicles.

Inner West Council has undertaken a traffic count to check that the requirements would be met for a shared zone.

5 TUNNELS

The concept design package includes three tunnels to be constructed under Constitution Road, Davis Street and Longport Street

5.1 LOCATIONS

Tunnels are proposed at:

- Constitution Road
- Davis Street
- Longport Street

5.2 DESIGN PRINCIPLES

It is intended that tunnels will be a "design and construct" (D&C) element of the construction tender. A suitably qualified tunnelling contractor will need to establish the best design and construction method to install the tunnels.

It is anticipated that the tunnels may be constructed either as jacked culverts or via cut-and-cover, however this is to be determined during the D&C process. Cut-and-cover construction is more likely to be appropriate at Davis Street and Constitution Road, while a jacked culvert is more likely to be required at Longport Street.

At the concept design stage, the tunnel horizontal and vertical alignment has been considered in relation to other structures and services, and a reasonable alignment has been proposed on the concept design drawings.

General structural advice has been sought, and desktop services checks have been undertaken, but further investigations are recommended to inform detailed design and construction.

5.3 GUIDELINES AND STANDARDS

Austroads Part 6A includes some specific design guidance relating to underpasses including tunnels. A key issue with tunnels is personal safety – Crime Prevention Through Environmental Design (CPTED) principles should be applied. CPTED principles relevant to tunnels include:

- Minimise tunnel lengths to minimise the distance path users are within the closed space
- Keep the entry visible – ensure that approaching path users are able to see the tunnel well before entering
- When entering the tunnel, path users should be able to see all the way through to the other side
- Avoid creating corners or obscured spaces which could be used as hiding places
- Manage vegetation near the tunnel to avoid creating hiding places
- Flatter approach embankments will reduce the perception of enclosure and assist with casual surveillance
- A height to width ration of 1:1.5 is preferable to reduce the perception of entering a narrow space
- Lighting is important to improve visibility and create a feeling of safety

Other design considerations include:

- Clearance – desirable vertical clearance is 2.5 m; 0.5-1.0 m clearance is also recommended between the path and tunnel walls
- Minimise grades on entry and exit ramps – along the GreenWay, grades should comply with AS 1428.1:2009
- Drainage – ensure the floor drains quickly and is shaped to reduce the build up of debris
- Maintenance – consider how the culvert will be cleaned – e.g. can it accommodate a small street sweeping vehicle?

5.4 DESIGN CONSIDERATIONS

The dimensions proposed for GreenWay tunnels are summarised in Table 3. This assumes that the tunnel structure is a box culvert.

The typical tunnel section proposed for the GreenWay tunnels is shown in Figure 17.

Table 3: Proposed tunnel dimensions

Dimension	Clear (m)	Total (m)
Preferred width	3.50	4.20
Minimum width	3.00	3.70
Height	2.46	3.135

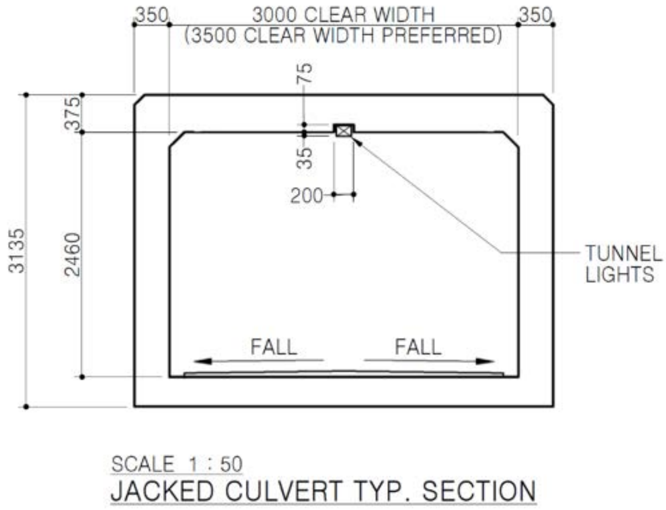


Figure 17: Typical tunnel section – Central Links (TLB 2018)

Note that the general design guideline for the GreenWay is a 3.5 m shared path, however if necessary, the path width could be reduced to 3.0 m through tunnels (without clearance on either side) as the width will have a measurable impact on the cost and constructability of tunnels.

The tunnels proposed along the GreenWay are each adjacent to an existing bridge over the light rail. It is therefore important to consider potential impacts on these existing structures when planning the alignment and construction methods for new tunnels. To minimise impacts, the following recommendations apply:

- Provide as much of an offset as possible between the existing bridge structure and proposed tunnel structure
- Manage impacts of vibration during construction
- It is likely that the material behind existing bridge structures includes backfill of unknown quality. Consider the potential for settlement and consolidation

Each of the proposed tunnels also passes under an existing road and there are multiple services within the road corridor. At this stage, not all of the service depths are known, however tunnel levels have been proposed to allow for typical depths and clearance requirements to underground services. Further information is provided in the concept design drawings on each specific site.

6 ELEVATED STRUCTURES

The concept designs propose several elevated structures, most significantly an upgrade of the existing Lilyfield Road bridge and a 280 m elevated path between Constitution Road and Hercules Street

At the following two locations, the concept design has relied on crucial structural engineering input:

- Lilyfield Road bridge upgrade
- Elevated shared path from Hercules Street to Constitution Road (including underpass under New Canterbury Road)

A structural engineering report, focusing on these two elements of the design, is included in Appendix B. The following sections summarise key issues and proposed design options.

6.1 LILYFIELD ROAD BRIDGE

At Lilyfield Road bridge, the existing bridge is deteriorating, and this affects its structural capacity as well as its design life.

It is understood that RMS intends to undertake remedial works to fix deterioration of the piers, and therefore this will extend the bridge's design life. These works are understood to be scheduled to take place in the near future.

Therefore it is considered worthwhile to invest in a landscape upgrade on the bridge deck. A key premise of the design is that it should be a load-neutral solution. Essentially the design involves:

- Removing some of the soil currently in place across the grassed area on the bridge. Depths will be reduced from a maximum of approximately 400-450 mm deep to a maximum of 300 mm deep
- Placing deeper planter beds over bridge piers
- Modifying the path on the southern side of the bridge, without increasing its load

SDA's report "Lilyfield Road Bridge" (20/12/2018) included in Appendix B presents a comparative structural review between the existing loadings on Lilyfield Road Bridge and the loadings associated with the proposed works for the Greenway, as documented in the McGregor Coxall 70% concept design package. It demonstrates that the proposed works can be constructed without increasing loads on the bridge. SDA's report has been submitted to RMS' bridge team for review.

Since 70% concept design stage, some modifications have been made to the works proposed on the bridge, however the solution remains equivalent in terms of proposed loadings.

6.2 ELEVATED PATH: CONSTITUTION RD TO HERCULES ST

Between Constitution Road and Hercules Street, the proposed shared path alignment is within the rail corridor, located on a steep embankment on the western side of the tracks.

This area presents a number of challenges. In particular, it involves challenging access for site inspections, survey, field testing and construction. As a result, there is a gap in the survey for about 110 m immediately south of Constitution Road.

There is some geotechnical information available from the light rail project, and this has been relied on in developing options for the structure.

SDA's report "Greenway Missing Links – Constitution Road to New Canterbury Road – Preliminary Scheme for Costing" (31 January 2019) presents:

- Structural design considerations
- Options considered
- Proposed solutions

Structural drawings provide more information for this section.

6.3 ELEVATED PATH: PARRAMATTA RD TO LONGPORT ST

This section of the path involves significant constraints, particularly at the northern end of Gadigal Reserve. Design options for this part of the route have been investigated in a separate report (Knights and McAuley 2020). This report resolved that the preferred option involves:

- An alignment on the eastern side of Gadigal Reserve.
- An underpass under Parramatta Road. This is discussed in more detail below.
- Either side of Parramatta Road, the path would be elevated over the Hawthorne Canal stormwater channel, supported on piers located at the edge of the channel. The concept design for this structure is also discussed in more detail below.
- In the part of Gadigal Reserve currently used as a dog-off leash area, the path can be constructed at-grade.
- A new bridge across Hawthorne Canal at the southern end of Gadigal Reserve (existing bridge to be replaced to allow construction equipment and future vehicle access to the eastern part of Gadigal Reserve).
- From this bridge south to Longport Street, the path is again an elevated structure, and climbs to meet the level of the proposed tunnel under Longport Street. The concept for this section is also discussed below.

6.3.1 PARRAMATTA ROAD UNDERPASS

An underpass under Parramatta Road was designed by TLB in 2018, and involves a structure suspended below the Parramatta Road bridge over Hawthorne Canal. The current concept design for the proposed underpass is based on TLB's design, but has been modified to raise the level of the structure, to minimise impacts on flooding. The revised design also reduces the grade required on the GreenWay path and minimises the level changes that path users will need to negotiate either side of Parramatta Road.

Construction of this underpass requires a few modifications to existing services:

- Immediately south of Parramatta Road, a section of 500 mm water main, approximately 25 m in length, is to be relocated. Currently this water main crosses over Hawthorne Canal immediately south of Parramatta Road and it conflicts with the proposed underpass. This water main is to be relocated to cross the channel approximately 15 m further south. The relocation of this water main is discussed in a separate Water Services Co-ordinator's report (Warren Smith and Partners, 2019).
- Under Parramatta Road, a disused 900mm gas main is to be downsized to 500 mm, to improve headroom and allow the underpass to be built at as high an elevation as possible. This is discussed in a memo from TLB ("Gas main options report" and associated "Bridge girder assessment report" in Appendix E).
- Also under Parramatta Road, the support beams for an existing 450 mm water main are to be removed to improve headroom. A section of this water main will need to be replaced with a self-supporting span. This is also discussed in the Water Services Co-ordinator's report (Warren Smith and Partners, 2019) .

6.3.2 PATH ABOVE HAWTHORNE CANAL

There are two sections of the GreenWay path, north and south of Parramatta Road, where the path is to be constructed over Hawthorne Canal. Following discussions with Sydney Water, the option drawn up in the concept design reflects their preferences, including:

- Piles located on the very edge of the stormwater channel, with minimal intrusion into the channel beyond the alignment of the existing channel wall (to minimise impacts on flows in the channel)
- Where each pile is located, the channel wall is shaped around it to create a smooth transition in the channel wall either side of the pile (to minimise the risk that the piles trap debris behind them)
- A temporary construction access ramp from Gadigal Reserve into the Hawthorne Canal channel, to allow construction equipment to access the channel and also be removed at the end of each work day. It is expected that a small piling rig can be used, which could fit under the relocated water main where a minimum clearance of 2.65 m is maintained, therefore a single access point may be sufficient to also access the northern side of Parramatta Road.

This concept will require further design development and consultation with Sydney Water to confirm design and construction details and seek approvals. A key risk to be considered is the potential impact on existing structures, including the stormwater channel itself and the brick retaining wall immediately above it. The brick retaining wall extends for more than 60 m and up to a height of 2.25 m on the southern side of Parramatta Road. It will be important to manage the impacts on these structures to minimise the risk of failure of the embankment behind them – this embankment has previously been assessed as having only a marginal level of stability (refer to Knights and McAuley 2020).

Considering this risk, SDA has suggested several alternatives for the piles at the edge of the channel (refer to SDA Central Links drawings in Appendix B, Walkway Types 6(a), 6(b) and 6(c) on sheets Sk7-Sk9.

- Structure Type 6(a) locates the piles for the GreenWay structure just behind the channel wall. This option is likely to be appropriate north of Parramatta Road and possibly for a short distance to the south, where there is room for the piles immediately behind the stormwater channel wall. It will not be appropriate where there is the brick retaining wall above the stormwater channel.
- Structure Type 6(b) locates the piles for the GreenWay structure within the channel wall. This could be appropriate where Type 6(a) is not feasible (e.g. where there is the brick retaining wall). This option has been developed to meet Sydney Water's stated preference to minimise the extent to which the piles protrude into the channel. However, this option has the highest potential impact on the channel structure, and also presents a potential risk to the integrity of the brick retaining wall above the channel. There are slope stability implications if either of these structures are impacted. These risks need to be considered at the detailed design stage.
- Structure Type 6(c) locates the piles for the GreenWay structure inside the channel, avoiding the wall of the channel except at its base. It indicates that a new wall would be constructed approximately 0.8-1.0 m from the existing channel wall, reducing the width of the channel, but providing a smooth edge to the channel, so there is no chance for debris to be trapped behind the piles. This option does not meet Sydney Water's stated preferences as well as Type 6(b), as it encroaches further into the channel. However it is recommended that this option be given further consideration at the detailed design stage, as it could be an appropriate compromise to minimise the risk of embankment failure while also maintaining sufficient capacity within the channel.

Note that the concept design drawings indicate a combination of Structure Types 6(a) and 6(b). However, wherever Type 6(b) is shown, it is recommended that Type 6(c) should also be considered as an alternative.

6.3.3 PATH BETWEEN GADIGAL RESERVE AND LONGPORT STREET

Between Gadigal Reserve and Longport Street, construction access is more straightforward, however several important constraints need to be considered in the design, as indicated on the concept design drawings:

- Under the Main Western Railway line, there is limited space between the rail bridge footing and the stormwater channel. The approximate expected extent of the rail bridge footing has been sketched in the concept design drawings, based on original drawings of the rail bridge. The extent of this footing will need to be confirmed on site. Sydney Water would prefer a minimum 1.0 m clearance to the stormwater channel structure. Therefore in this section, single central piles have been indicated in the concept design drawings, instead of the pairs of piles proposed elsewhere.
- South of the Main Western Railway line, there is a need to maintain an appropriate clearance to the support piers for the heritage whipple truss bridge structure, and minimise any impact to this structure (e.g. vibration) during construction.
- Immediately north of Longport Street, there is a 1200 mm above-ground water main. This constrains potential pile locations. Future maintenance access to the water main also needs to be considered in consultation with Sydney Water.
- A colony of microbats is known to live within the two tunnels perpendicular to the GreenWay shared path immediately north of Longport Street through which the 1200 mm above-ground water main continues. A bat light screen structure is proposed for approximately 14 m from the Longport Street tunnel to limit the impact of the shared path lighting on the bat colonies. The design of this structure requires careful consideration during detailed design by a specialist designer to ensure that light spill from the shared path is minimised.

6.4 OTHER ELEVATED PATH SECTIONS

Beyond the three sections of the GreenWay described above, there are several other locations where ramps and small bridges are proposed as part of the concept designs, to facilitate level changes or waterway crossings. Structural design input will be needed for these elements at the detailed design stage.

7 WATERWAYS, STORMWATER AND WSUD

One of the objectives along the GreenWay is to improve waterway health, and the concept design proposes works including an ecologically-friendly seawall, creek restoration and multiple stormwater treatment systems

7.1 LOCATIONS

Waterway and stormwater management works are proposed at the following locations:

- Iron Cove (seawall upgrade between UTS Rowing Club and City West Link overpass)
- Gadigal Reserve (upgrade of two drainage lines running through the eastern part of the reserve)
- Lewisham West (proposed wetland NE of light rail stop)
- Terry Road (drainage improvement works to reduce flooding of property at the Waratah Mills "Hopper" building)
- Hercules Street open space (creek restoration works plus two small wetlands)
- Streetscape works at both bike boulevards (Weston Street and Ness Avenue) also involve drainage modifications and some stormwater treatment opportunities.

Each of these is discussed in the following sections.

7.2 IRON COVE SEAWALL

Between the underpass under the City West Link Road and the UTS Rowing Club, the GreenWay path and the Bay Run path are located close to the water's edge, behind a seawall. Council has some funding available to repair and upgrade this seawall, as well as for the proposed path upgrade.

Along much of this stretch, the path alignment can remain unchanged, but in some locations it is proposed to build the path out slightly further towards/into the Bay, in order to widen the path and avoid constraints on the landward side. Therefore some sections of seawall will need to be rebuilt.

Other sections of the seawall can remain in the same location, but are due for repair or upgrade. When the path is upgraded, it would be logical to undertake seawall works at the same time, even where the alignment of the seawall doesn't need to change.

Seawall upgrade works are also an opportunity to improve habitat on the wall, this is discussed further below.

7.2.1 EXISTING CONDITIONS

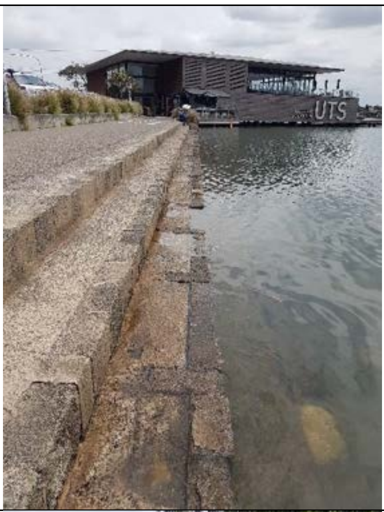
The existing seawall is in variable condition. In some areas there is a particular erosion issue, common at seawalls, where water is ponding at the top of the wall and draining out through gaps in the wall, taking sediment with it. These sections of the seawall need substantial repairs/upgrades.

Other parts of the seawall are in better condition; the seawall is generally stable but with deterioration and loss of grout in some sections.

Two stepped sections of the wall are in reasonably good condition.

In order to scope proposed works, the condition of the existing seawall has been reviewed and is summarised in Table 4. Proposed works are also summarised in Table 4.

Table 4: Iron Cove seawall scoping assessment

Reach (description)	Typical image	Nature of existing seawall	Proposed works
UTS Rowing Club to approx. 36 m east		Sandstone steps in reasonable condition Some landscape value as attractive seating steps Minimal habitat value	Widen path on Bay side (landward side constrained by car park). Modify/re-build seawall to accommodate increased path width Incorporate habitat into seawall
From end of stepped wall to a point between car park and GPT (approx. 30 m)		Sandstone block wall, with section between top of wall and path covered with stone pitching. Some vegetation growing in gaps, however there is minimal evidence of erosion. Some deterioration and loss of mortar, particularly around pipe outlets.	Widen path on Bay side (landward side constrained by car park). Re-build seawall to accommodate increased path width Incorporate habitat into seawall
From point between car park and GPT to stepped concrete wall (approx. 70 m)		Sandstone block wall to approx. 1.5 m AHD Vegetated section between top of wall and path; minimal evidence of erosion. Some deterioration and loss of mortar, particularly around pipe outlets. Three existing trees between seawall and path, however the southernmost tree appears to be dead.	In most of this section, there is space to widen the path on the landward side, without changing the alignment of the seawall. However seawall upgrade works are proposed to bring condition up to the standard of other new sections, and to add habitat.

Reach (description)	Typical image	Nature of existing seawall	Proposed works
Stepped concrete wall (approx. 58 m)		Concrete steps in good condition Top of wall = approx. 1.4 m AHD	No works proposed
From stepped concrete wall to Lilyfield Road bridge (approx. 66 m)		Sandstone block wall to approx. 1.1-1.3 m AHD Largely bare soil and evidence of significant erosion between top of wall and path Path is at around 1.3-1.5 m AHD	Widen path and raise levels to 1.5 m AHD. Also raise height of seawall to 1.5 m AHD Install adequate drainage between path and seawall Rebuild seawall including geotextile underlay. Seek opportunities to incorporate habitat into seawall
Under Lilyfield Road bridge (approx. 25 m)		Sandstone block wall with concrete on top, to approx. 1.2 m AHD Bare soil between wall and path, with some evidence of erosion	As above
From Lilyfield Road bridge to City West Link underpass (approx. 72 m)		Seawall covered in mass concrete, with row of sandstone blocks at the top, grouted in place Top of sandstone blocks is approx. 1.4-1.5 m AHD Bare soil between wall and path, with some evidence of erosion Note line of nine existing trees immediately behind seawall in this reach	Work with existing levels and retain existing trees Install adequate drainage between path and seawall Rebuild seawall including geotextile underlay. Seek opportunities to incorporate habitat into seawall

7.2.2 PROPOSED WORKS

In general, the proposed seawall works, as shown in the concept design drawings, involve:

- Keeping the existing seawall structure in place
- Covering the existing seawall with geotextile and a layer of rip-rap, secured with an anchor trench at the base of the seawall
- Adding at least one block to the top of the existing wall, to anchor geotextile in place out of sight, and raise the top of the seawall to at least 1.5 m AHD
- Installing a vegetated drainage trench behind the top of the wall, to capture surface runoff and convey it to controlled discharge points through the wall
- Stormwater pipes will need to be extended through the rip-rap
- The intention is to include intertidal pool and oyster habitat within the rip rap wall – specific options are discussed further below
- A salt marsh ledge is also an option in some locations

In order to build over the existing wall and in one location extend 1 m further into the bay, approval will be required from NSW Roads and Maritime Services, and this should be sought at the detailed design stage.

Pearl Bay in Mosman provides a reasonable precedent and template for proposed works at Iron Cove. The seawall at Pearl Bay (pictured in Figure 18 prior to works) suffered from similar drainage issues. Works undertaken at Pearl Bay (pictured in Figure 19) retained the existing structure but added rip-rap on the seaward side and a planted strip and a path on the landward side. One section also includes a salt marsh ledge (the design drawing is shown in Figure 20).

Figure 18: Pearl Bay prior to seawall works

Figure 19: Upgraded seawall at Pearl Bay, NSW

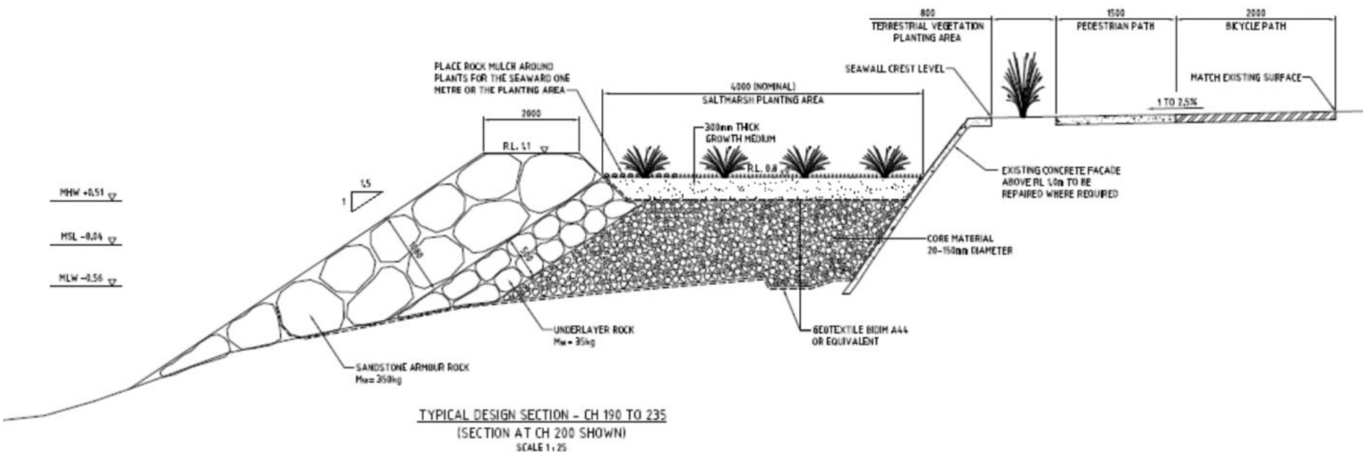


Figure 20: Pearl Bay design section with salt marsh ledge (Covich and Makim, 2015

7.2.3 SEA LEVELS

Currently, in this section of the Bay Run and northern end of the GreenWay, the lowest parts of the path are around 1.4-1.5 m AHD. Where upgrade works are proposed, the path will be finished at a minimum of 1.5 m AHD, however one section (immediately west of Lilyfield Road bridge) will remain at 1.4 m AHD. In the context of current sea levels, shown in Table 5, this is equivalent to a still water level that would occur once in 50-200 years.

Overtopping of the path is likely to occur somewhat more frequently than this, when high tides coincide with storm surges and/or wave action, however at the moment, overtopping of the path is likely to be infrequent enough that it's not a significant problem.

As sea levels rise, path inundation will become more frequent. Projected sea level rises shown in Table 6 suggest that if sea level rise is in the MEDIUM to HIGH range:

- By 2050 the still water level is expected to reach 1.4 m AHD more than once a year, and 1.5 m AHD each 1-5 years
- By 2100 the still water level is expected to reach 1.5 m AHD several times each year

Sea level rises associated with the LOW scenario are less significant.

Table 5: Sydney Harbour design still water levels (2008)

ARI (years)	Maximum Level	
	M ISLW	m AHD
0.02	1.89	0.965
0.05	1.97	1.045
0.10	2.02	1.095
1	2.16	1.235
2	2.20	1.275
5	2.24	1.315
10	2.27	1.345
20	2.30	1.375
50	2.34	1.415
100	2.36	1.435
200	2.38	1.455

Notes: 1. Values derived from DECCW extreme value analysis (Gumbell Distribution).
2. ISLW refers to Indian Springs Low Water Datum.

Overtopping of the path could become a nuisance by 2050, however rather than raising path levels in the short section proposed for upgrade, it is recommended that Council simply plans for more frequent inundation, as:

- It only makes sense to raise the path in short sections if there is a long-term strategy to raise levels elsewhere around the Bay
- Raising the levels would add significant extra cost and challenges with drainage, services, trees, access, etc.

Table 6: Sydney Harbour design still water levels (2050 and 2100)

Table A1: Sydney Harbour Design Still Water Levels for Future Planning Horizons (Incorporating Sea Level Rise)

ARI (Years)	2008 Design Still Water Levels (m AHD)	SLR Scenario (L, M, H)	2050 Design Still Water Levels (m AHD)	2100 Design Still Water Levels (m AHD)
0.02	0.965	L	1.005	1.125
		M	1.175	1.495
		H	1.345	1.855
0.05	1.045	L	1.085	1.205
		M	1.255	1.575
		H	1.425	1.935
0.10	1.095	L	1.135	1.255
		M	1.305	1.625
		H	1.475	1.985
1	1.235	L	1.275	1.395
		M	1.445	1.765
		H	1.615	2.125
2	1.275	L	1.315	1.435
		M	1.485	1.805
		H	1.655	2.165
5	1.315	L	1.355	1.475
		M	1.525	1.845
		H	1.695	2.205
10	1.345	L	1.385	1.505
		M	1.555	1.875
		H	1.725	2.235
20	1.375	L	1.415	1.535
		M	1.585	1.905
		H	1.755	2.265
50	1.415	L	1.455	1.575
		M	1.625	1.945
		H	1.795	2.305
100	1.435	L	1.475	1.595
		M	1.645	1.965
		H	1.815	2.325

7.2.4 HABITAT OPPORTUNITIES

Where the seawall is to be re-built, a rip-rap wall is proposed. This provides some habitat in the voids created amongst rocks of different sizes and shapes, placed randomly. Habitat opportunities could be improved by incorporating some more targeted habitat elements.

Within the height range of the existing and proposed sea wall, the following habitat types could potentially be accommodated in small ledges or pockets:

- Coastal salt marsh, which typically occurs at around 0.7-1.1 m AHD (based on current sea levels). Different salt marsh plants occur at different levels within this range
- Intertidal pools, which occur between regular high and low tides (approx. -0.5 to 0.4 m AHD)
- Oyster-friendly substrate – oysters tend to colonise the zone between Mean Sea Level and Mean Low Water, approx. -0.4 to 0 m AHD

At the Iron Cove seawall, the specific habitat options recommended for further investigation at detailed design stage are summarised in Table 7.

Table 7: Iron Cove seawall habitat opportunities

Habitat type	Typical image	Notes
Salt marsh ledge	 Salt marsh in the Cooks River	A salt marsh ledge has been proposed in the 36 m reach immediately south-east of the UTS Rowing Club (Section A). This area is subject to future survey, but in principle the concept involves incorporating a salt marsh ledge on top of one of the existing steps, at an appropriate level. Incorporating a salt marsh ledge is also an option elsewhere, at the top of the rip-rap wall, and this is presented as an alternative option. The option with the salt marsh ledge would involve construction works extending further into the Bay beyond the existing seawall, and would involve additional expense. Therefore rather than incorporating a salt marsh ledge along the full extent of works, it could be considered for some sections in short stretches.
Walled tidal pool	 Walled tidal pool at Pearl Bay, NSW	A walled tidal pool could potentially be incorporated at one or more locations beyond the seawall, however the recommendation at this stage is to focus on smaller tidal pool habitat options, which could be integrated within the seawall, rather than attempting to accommodate a large structure beyond the seawall.
Tidal pool ledge	 Sandstone block tidal pool ledge, Sydney	A small tidal pool ledge is presented as part of the alternative option at Section A. It could be built on one of the existing steps by installing a lip on the edge of the step. There are a few reasons why this option is not preferred: – It results in a steeper seawall, which may need a barrier at the top – The steeper design could present slope stability issues – It is a more expensive option
Tidal pool blocks	 Manufactured tidal pool units in Singapore	Concrete blocks such as those pictured are typically 3D printed and therefore design options are open-ended. In general, tidal pools with more complex surfaces provide better habitat. Blocks such as those pictured could be incorporated on an existing ledge or could even be placed within the rip-rap wall.

Habitat type	Typical image	Notes
Manufactured tidal pool pods	 ECOncrete tide pool, NY USA	This example is similar to the concrete blocks pictured above but is a random shape about 1 m across. It is shown integrated within a rip-rap wall.
Mini intertidal pools	 “Flower pot” concrete tide pool attached to a vertical seawall, Sydney	These “flower pot” tidal pools have been retrofit to vertical seawalls in Sydney Harbour. This specific design is more appropriate to a vertical wall, however the example provides an indication that even a very small tidal pool can provide useful habitat. The pictured example is approximately 0.25 m across.
Precast concrete blocks with mini pools	 Pre-cast concrete “Bioblock” with integrated tidal pool habitat (Colwyn Bay, UK)	This example is a precast concrete block, 1.5 m square, with tidal pools incorporated in the top surface. The example shown was installed within a rip-rap wall. This type of concrete block is likely to be cheaper and simpler to manufacture than the 3D-printed concrete examples shown above.

Habitat type	Typical image	Notes
Core drilled tidal pools	 Tidal pool core drilled into rock (UK)	Small tidal pools can be core drilled into rock – for example larger stones within the rip-rap wall could be drilled with tidal pools. These would require more careful placement within the rip-rap wall, to locate the pools at the right elevation and angle.
Oyster bags/mats	 Oyster bags in MA, USA	Oysters were once abundant in the area, and are still present in relatively low abundance around Iron Cove. Oysters will colonise rock surfaces, however old oyster shells provide a preferred substrate for juvenile oysters. Therefore to enhance habitat for oysters, old oyster shells can be used as a substrate to encourage oyster colonisation. Oyster shells can be placed in bags or gabion baskets, attached to mats or cemented into blocks. These could then be placed randomly within the rip-rap wall. A surface colonised by oysters provides habitat for other invertebrates, by reducing the force of wave action and creating sheltered positions amongst the oyster shells. Therefore oyster habitat is also habitat for other marine invertebrates. Be aware that some options (e.g. oyster shell bags) are likely to break down over time.

7.3 GADIGAL RESERVE STORMWATER

On the eastern side of Gadigal Reserve, there are two stormwater drainage channels which cut through the open space. These are pictured in Figure 21 and Figure 22. Each of these is an open concrete U-shaped channel. The southern channel is approximately 0.7 m wide and the northern channel 0.9 m wide. Each of them has been bridged with a simple set of timber planks.

Figure 21: Southern drainage channel in Gadigal Reserve

Figure 22: Northern drainage channel in Gadigal Reserve

The concept design proposes that these concrete channels be removed and replaced with more natural drainage lines. The objectives are:

- To make this space safer and more accessible
- To improve habitat
- To improve visual amenity

Natural channels will still need to convey the flows from upstream catchments without instability, scour or erosion. There also may be opportunities to improve stormwater quality.

The upstream catchments are shown in Figure 23. They are approximately:

- 5,900 m^2 upstream of the northern channel
- 29,700 m^2 upstream of the southern channel

An initial estimate of design flows has been undertaken based on the Urban Rational Method (AR&R 1987). Design flows are summarised in Table 8.

Table 8: Gadigal Reserve design flows

Annual Exceedance Probability	Design Flowrates (m^3/s)	
	Northern catchment	Southern catchment
50%	0.12	0.46
20%	0.17	0.69
10%	0.21	0.86
5%	0.25	1.04
2%	0.32	1.35
1%	0.37	1.57

To provide a similar capacity to the existing concrete channels, a channel lined with vegetation and rocks would need to have approximately the following dimensions:

- Base width: 0.5 m
- Top width: 2.5 m
- Depth: 0.4 m

The concept plans accommodate these dimensions.

There is potentially an opportunity to install a stormwater treatment system at Gadigal Reserve – ideally in the area identified for bank naturalisation immediately north of the southern stormwater outlet. The suggestion here is to create a terraced area of approximately 150 sqm, which is approximately 0.5% of the upstream catchment area. This is future works, beyond the current budget, therefore it is recommended that stormwater treatment be investigated further once funding becomes available.

Figure 23: Eastern Gadigal Reserve stormwater catchments

7.4 LEWISHAM WEST WETLAND

At Lewisham West, a wetland is proposed on the eastern side of the light rail line, immediately south of the light rail crossing. The focus of this wetland is habitat and ecological restoration rather than stormwater treatment, however it will still be important to ensure that the wetland is fed by a suitable water source that can sustain it. Many native Australian wetland plants are well adapted to periods of drought, however if dry spells become too frequent or prolonged, the system could cease to function as a wetland. The wetland location is in an existing depression in the landscape that provides some existing flood detention. The proposed wetland levels have been designed to minimise cut and fill and to ensure that the flood detention capacity is not reduced.

Therefore local catchments have been investigated for opportunities to divert surface flows via gravity.

Local catchments are shown in Figure 24 and summarised in Table 9.

Figure 24: Potential wetland catchments at Lewisham West

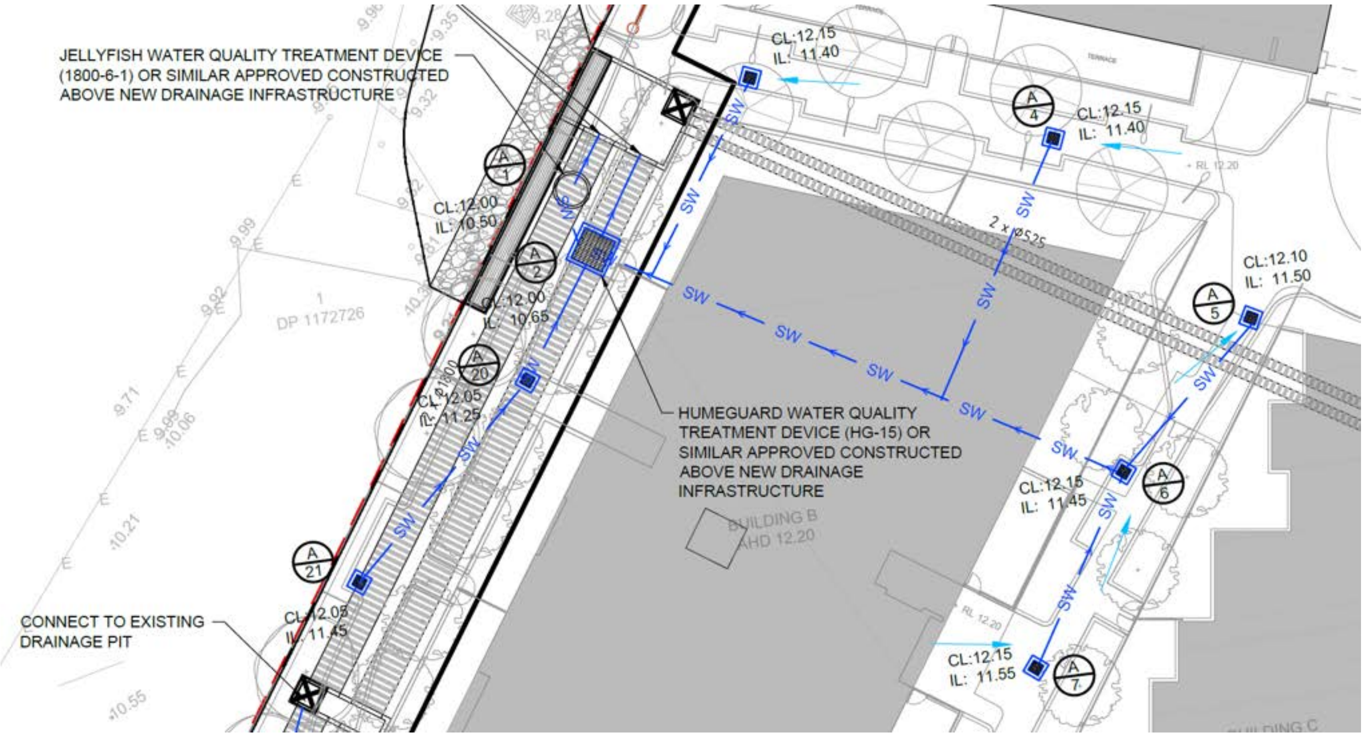


Figure 25: Excerpt from stormwater drainage plans for 78-90 Old Canterbury Road (Karimbla Construction Services 2014)

Table 9: Lewisham West potential wetland catchments

Catchment	Area, m²	Potential diversion location + level
Northern part of Luna development	4,450	Downstream of either Humeguard (planned IL = 10.65 m AHD) or Jellyfish filter (planned IL 10.50 m AHD), refer to Figure 25. Recent survey did not pick up invert levels so they need to be confirmed on site
Driveway catchment	220	Local drainage pit, planned IL 11.15
Forecourt catchment	1,360	While 2014 stormwater drainage plans indicate a pit with IL 10.50, 2017 survey suggests IL more likely to be <9.50, based on surrounding levels. It is possible that this catchment is already being diverted to a new raingarden within the forecourt.
Hudson Street upper catchment	670	Pick up surface runoff upstream of first pit
Hudson Street lower catchment	1,020	Pick up surface runoff upstream of pit at end of cul-de-sac, depending on which side of the existing pit a diversion pit is placed, this catchment may be divided into a subcatchment of approximately 750 m^2 (south of round-a-bout including western side of McGill St) and 220 m^2 (north of round-a-bout).
McGill Street catchment	590	Pick up surface runoff upstream of pit at northern end of street

A daily water balance model was set up for 30 years, to test a range of catchment areas and understand the frequency of dry spells in the wetland. Results are summarised in Figure 26 and Figure 27. Important assumptions in this analysis are:

- Only the impervious catchment area has been represented. The potential catchments upstream of the wetland have high impervious fractions, but the pervious proportion also needs to be accounted for
- Dry times and dry spells were counted when the water level reached zero in the wetland. In each scenario, there were also periods of time in which the water level was very low, but these were not counted
- A dry spell was counted as a period of consecutive days with zero water level

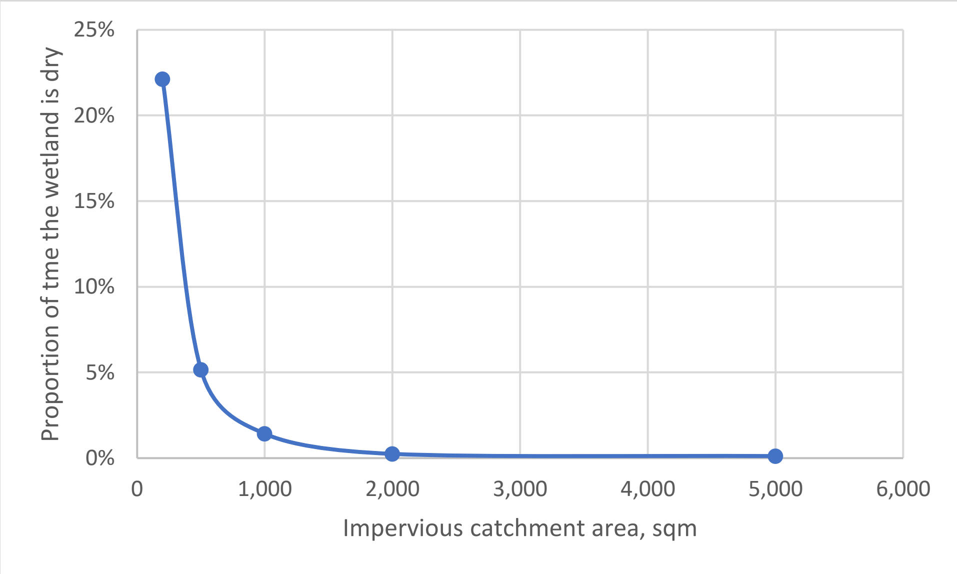


Figure 26: Lewisham West wetland – frequency of a drying based on different catchment areas

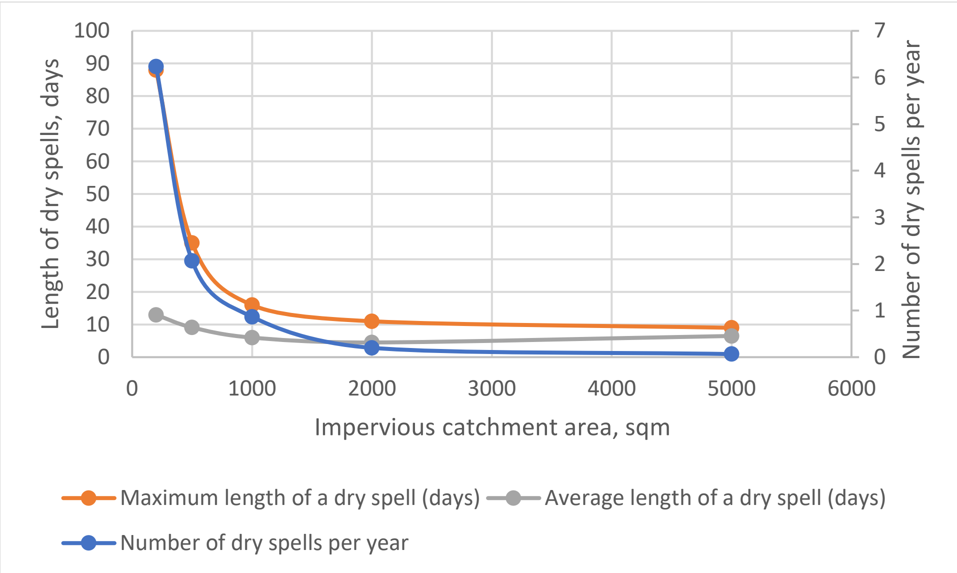


Figure 27: Lewisham West wetland – frequency and severity of dry spells based on different catchment areas

Results in Figure 26 and Figure 27 suggest that to minimise the frequency and severity of dry spells, a minimum impervious catchment area of 1,000 m^2 should be diverted to the wetland. An impervious catchment area of 2,000 m^2 would be preferable.

The northern Luna development catchment (4,450 m^2) would be an ideal catchment to divert to the wetland, and this is shown as the preferred option on the concept design drawings. However at this stage there is some uncertainty about the levels within this drainage system. While the drainage plans shown in Figure 25 suggest an invert level of 10.50 m AHD at the Jellyfish filter, it may not have been installed at this level. The 2017 survey has not picked up this invert level, but elsewhere, the 2017 survey suggests that drainage has been installed significantly deeper than shown on the 2014 concept plan which would make the grade infeasible to divert to the wetland location.

Therefore an alternative option has also been shown on the concept design drawings, which provides more certainty about the levels. The alternative option involves installing new pits and pipes to pick up surface runoff from the Hudson Street (lower) and McGill Street catchments, before it drops into the deeper drainage system. The combined total catchment area is estimated at 1,333 m^2, and this is almost 100% impervious.

Whichever catchment/s are diverted to the wetland, there will be periods where inflows are low and residence times are relatively long. Long residence times can contribute to algal blooms and weed outbreaks, therefore it is recommended that in this wetland, consider including a small (potentially solar) pump to recirculate flows in dry times.

7.5 TERRY ROAD DRAINAGE

Terry Road runs between Windsor Road and the light rail corridor immediately south of the Waratah Mills apartment complex. At the downstream end of Terry Road, nuisance flooding is a problem. A typical event is pictured in Figure 28.

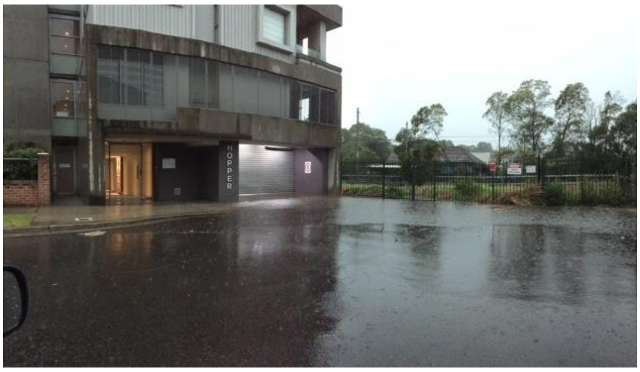


Figure 28: Nuisance flooding at the downstream end of Terry Road

Water ponds in the end of the cul-de-sac and reaches a level where it overtops the driveway of the Waratah Mills "Hopper" building, flooding the basement car park.

Downstream of Terry Road, there is an existing drainage swale and stormwater pit in the rail corridor, pictured in Figure 29 and Figure 30. The capacity of this existing system appears inadequate for the catchment, and some analysis has been undertaken to understand where the capacity issue occurs. The capacity of the following elements has been estimated:

- Ponding volume at the end of the road
- Weir capacity at the end of the road (where flows overtop the footpath into the light rail corridor)
- Swale capacity in existing condition
- Pipe capacity within the rail corridor

Figure 29: Existing swale downstream of Terry Road (estimated Manning's n = 0.03)

Figure 30: Existing pit inlet downstream of Terry Road

The catchment area at Terry Road is approximately 11,900 m^2 and is shown in Figure 31. Peak flows have been estimated using the Urban Rational Method (AR&R 1987) as shown in Table 10.

Figure 31: Terry Road catchment

Table 10: Terry Road peak flows

Annual Exceedance Probability	Design Flowrates (m^3/s)
2EY	0.12
1EY	0.17
50%	0.20
20%	0.31
10%	0.39
5%	0.47
2%	0.61
1%	0.71

Capacities of the key elements of the drainage system are shown in Figure 32 and Figure 33. These results show:

- At the weir, the maximum depth is only 0.27 m before flows would overtop the Hopper driveway, at which point the flow over the weir has been estimated at approximately 0.45 m^3/s (close to the 5% AEP (20 year ARI) peak flow)
- At the swale, there is potentially up to a maximum 0.35 m head difference from the upstream to the downstream end of the swale, equating to a hydraulic grade line (HGL) slope of 1.5%. This would result in an estimated capacity of only approximately 0.10 m^3/s, a flow which occurs more than twice per year
- The pipe would need a HGL more than 10% grade to convey the 20% AEP (5 year ARI) peak flow. It would need a HGL grade of approximately 5% to convey the 50% AEP (2 year ARI) peak flow. Pipe levels are unknown but its capacity is likely to be even less than this.

This suggests that the capacity of the swale is likely to be a limiting factor in the system, however if the swale capacity was increased, then the pipe capacity would become the limiting factor. It is also worth noting that blockage has not been accounted for in the analysis above. Figure 34 shows some evidence of blockage at the end of Terry Road, in both the weir and the swale.

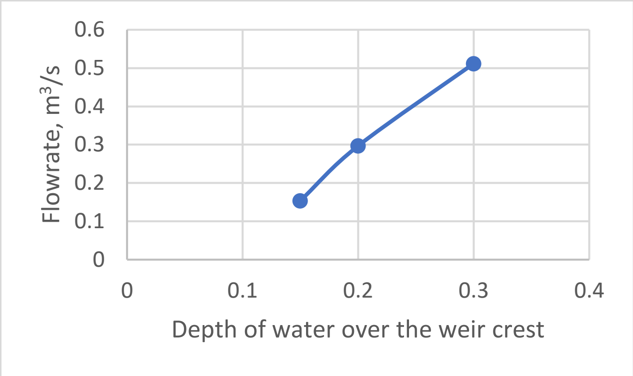


Figure 32: Estimated flow capacity over the weir at Terry Road

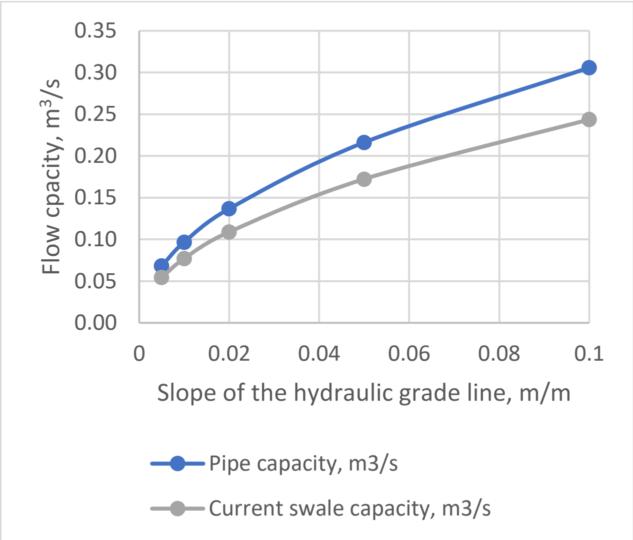


Figure 33: Flow capacity in the swale and stormwater pipe downstream of Terry Road

Figure 34: Evidence of blockage at the end of Terry Road

GreenWay shared path construction works are an ideal opportunity to undertake stormwater drainage works at the end of Terry Road and in the rail corridor, and the objective is to design a system that can convey the 20% AEP (5 year ARI) peak flow before any overflow occurs into the adjacent driveway. It is also recommended that the system be designed to cope with some blockage.

To meet this design standard will mean upgrading the system all the way to the Sydney Water trunk drainage infrastructure, which crosses under the light rail corridor approximately 50 m downstream of Terry Road.

Note that the option to divert flows along Windsor Road to reduce flows in Terry Road is not recommended, as it would put extra pressure on the drainage system in Windsor Road. At the low point in Windsor Road, Nos 75 and 77 are also likely to be flood prone, as there is a relatively low threshold at which flows would break out from the street into these two properties. Negative impacts on this system are avoidable.

The following works have been proposed in the concept design package:

- New pit at the end of Terry Road., sized at 900 mm x 900 mm to accept the 20% AEP peak flow
- New pipe from this pit to the Sydney Water trunk main, sized at 525 mm to convey the 20% AEP peak flow
- Expanded swale, to accept flows above the 20% AEP or accept overflows when blockage affects the capacity of the system
- Retain the existing 300 mm pipe in the rail corridor as is

The pit and pipe sizing were checked both via hand calculations and in DRAINS. The DRAINS long section plot is shown in Figure 35. This assumes no blockage.

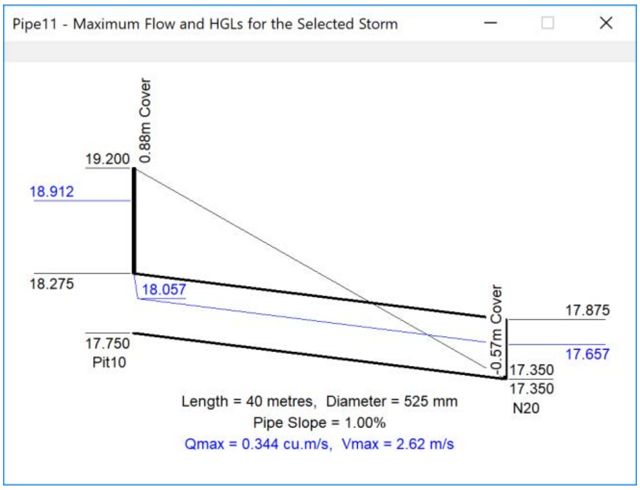


Figure 35: Proposed pit and pipe, long section plot

The proposed swale shown on the concept design drawings has dimensions of 0.5 m at the base, 2.5 m at the top and 0.25 m deep. This has been sized to work around existing shrubs and trees, and is considered a maximum size for the site. This swale would provide approximately 8 m^3 capacity for ponding (replacing the ponding in the road), but its bed grade would be only around 0.25%. The conveyance capacity of this swale would be dependent on the vegetation in the swale. Flows have been plotted for two different Manning's n values in Figure 36. An n value of 0.045 is typical of long grass and an n value of 0.08 is typical of dense sedges or shrubs.

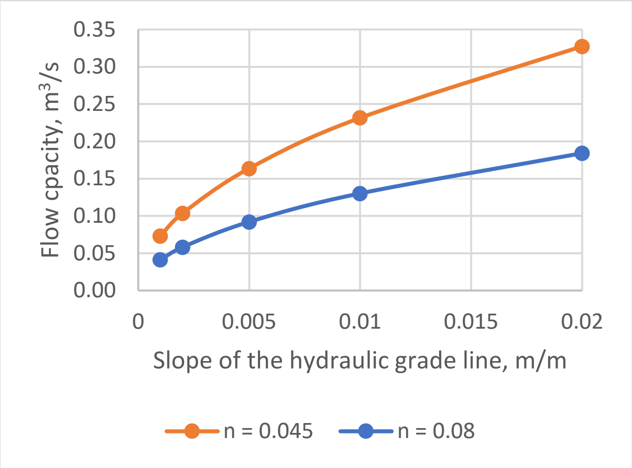


Figure 36: Proposed swale capacity

The maximum capacity of this swale is only likely to be around 0.12 m^3/s (based on HGL slope equivalent to bed slope). The swale would need to be much bigger (with a greater impact on the site) to convey the 20% AEP peak flow, hence it is recommended that the pipe be sized for the 20% AEP flow and the swale be used to provide some overflow capacity in the event of partial blockage.

It is possible that the system could also be designed to direct frequent low flows into the swale, to provide passive irrigation and water quality improvement. This option should be considered at the detailed design stage.

7.6 HERCULES STREET OPEN SPACE

Within the Hercules Street open space, proposed works include restoration of an existing drainage channel to improve its habitat value, and wetlands for stormwater treatment.

7.6.1 CHANNEL RESTORATION

In the Hercules Street open space, it is the only place along the GreenWay where stormwater drainage has not been piped or channelised. An open, earth-lined and vegetated drainage channel runs through the open space, beginning behind Nos. 43/45 Hercules St and continuing approximately 220 m to a headwall behind No. 85 Hercules Street.

The channel collects flows from surrounding drainage lines and delivers them back into an underground drainage system at its downstream end.

The condition of the channel is largely unknown at this stage, but aerial images show that it is clearly well-vegetated. Residents backing onto the drainage line reported nuisance flooding on their properties.

The concept design plans anticipate an opportunity to improve this drainage channel, including:

- Introducing a more diverse channel morphology, which will provide more diverse habitat opportunities
- Revegetation with locally native species
- Capacity improvement and/or stabilisation (if either proves necessary)
- Minor realignment to accommodate GreenWay path works (however the general intention in this area is to minimise earthworks)

In the concept design, the existing creek alignment has largely been retained from the upstream where it is believed flows surface at a surcharge pit. The existing creekline hugs the eastern side of the path until reaching the rear of no. 55 Hercules St. At this point the creek alignment is slightly modified as it crosses to the western side of the shared path, to facilitate a shorter shared path bridge span. At detailed design stage, the channel should be modelled and proposed sections tested to ensure they will provide a stable solution with adequate capacity, reducing nuisance flooding where possible. It will be important to ensure that the proposed works do not increase the risk or severity of flooding on private properties.

7.6.2 WETLANDS

During concept design development, two potential locations were identified for wetlands, where stormwater could be brought to the surface and water body created with relatively minor earthworks. These have the following areas (approximate areas at normal water level):

- Northern/upper pond: 45 m^2
- Southern/lower pond: 150 m^2

There are several large stormwater catchments upstream of the Hercules Street open space, and some large drainage pipes running through the space, but most of these are quite deep. In order to get water into these two water bodies, local catchments have been investigated.

Catchments upstream of these two water bodies are shown in Figure 37. At the northern/upper pond, the intention is to divert flows from the local catchment which joins the rail corridor between Nos. 43 and 45 Hercules Street. Levels are to be confirmed, but it is expected that flows from this catchment can be daylighted at a higher level than flows within the drainage channel.

Figure 37: Catchments upstream of the Hercules Street open space

Between Nos. 43 and 45 Hercules Street, a pipe (size unknown, GIS data indicates 300 mm diameter) drains a total estimated catchment area of 1.5 ha, including properties on Terrace Road, Consett Street and Hercules Street. The available wetland area is approximately 1.4% of this catchment area, which is a reasonably good sizing ratio. Wetlands which are very small in relation to their catchment area tend to be prone to sedimentation, water quality problems and other management challenges, therefore rather than diverting any more stormwater into the wetland, it is proposed to treat this 1.5 ha catchment.

It is recommended that the upper pond be designed as an inlet/sediment pond, while the lower pond be designed as a macrophyte zone. The ratio between the areas is appropriate for this approach.

This strategy has been modelled in MUSIC, assuming that:

- The inlet pond will have a permanent pool volume of approximately 20 m^3
- The macrophyte zone will have a permanent pool volume of approximately 30 m^3
- Both inlet pond and macrophyte zone will have 0.5 m extended detention

It is estimated that the wetland will remove the following pollutant loads:

- Total suspended solids: 390 kg/year
- Total phosphorus: 0.70 kg/year
- Total nitrogen: 3.9 kg/year

These represent 38%, 27% and 16% of the total catchment loads respectively.

The concept design drawings show:

- A 300 mm pipe to divert flows into the inlet pond
- A low-flow outlet from the inlet pond to the macrophyte zone, recommended as a 200 mm

HDPE pipe (with an estimated capacity of 60 L/s, appropriate for the size of the macrophyte zone)

- A high flow discharge pipe (nominally 300mm) from the inlet pond outlet pit into the drainage channel
- The macrophyte zone will also need a riser outlet to control residence times
- The macrophyte zone has been designed to accommodate existing underground drainage infrastructure, but assumes that a short section of open channel will be replaced by a pipe, so the wetland can be built over this system and operate independently.

Note that there are some important details of the existing stormwater drainage system that will need to be confirmed at detailed design stage:

- Exact location and depth of the drainage line between Nos. 43 and 45 Hercules Street.
- Within the rail corridor, the concept design proposes that flows from the 3.3 ha catchment emerge into the drainage channel via an existing pit modified to be a surcharge pit behind No. 45 Hercules Street and the headwall (see Figure 39) will be demolished The understanding of existing infrastructure in this area is based on an image from 2008 which appears to show this (Figure 38) and 2016 aerial photography in Figure 39 which clearly shows a pit and headwall at the top of the channel. The headwall was not picked up on the 2018 survey, but vegetation is now dense in this area. There is some indication that a pipe may continue downstream of this point (GIS data indicates a pipe size of 450 mm). If it is proven that a pipe continues downstream of the position where the headwall is expected to be found, then some redesign will be required.
- In the vicinity of the lower wetland, there is a gap in the survey. The existing inlet structure to the 1650 mm drainage pipe (immediately downstream of the short section of open channel) falls into this gap. An invert level is shown but no other details of the structure.

Figure 38: 2008 photograph showing flows emerging into open channel

Figure 39: 2016 Aerial photo showing headwall behind 45 Hercules Street

7.7 STREETSCAPE DRAINAGE AND RAIN GARDENS

Where new kerb blisters or other vegetated areas within roads are proposed as part of the concept design scope, each of these locations has been assessed in terms of the potential to build rain gardens. The following factors were considered:

- Catchment area
- Presence of underground drainage in the vicinity
- Presence of other underground services

In general, the design approach has been as follows:

- Some locations have no catchment area
- Where catchments are relatively large and/or grades are steep, it is recommended to keep blisters separate from stormwater drainage and convey flows in an open gutter (offsetting blisters from the kerb).
- Where catchments are relatively small, and/or where proposed works will create a trapped low point, it is recommended to build a rain garden. In some cases this approach can avoid the need for new pits and pipes.
- In most cases, it is recommended that these are built as simple swales, which keep flows on the surface and are feasible even where there is no underground drainage and/or where there are underground service constraints.

A summary of these opportunities is presented in Table 11.

Table 11: Streetscape stormwater treatment opportunities

Location	Proposed works	Catchment areas (sqm)	Underground drainage	Underground service constraints	Recommendation
Lilyfield Road	Expanding existing blisters and converting to vegetated blisters	None	NA	NA	No stormwater treatment opportunity
Weston Street – north end	Road closure including vegetated garden beds	E: 360 W: 3,100	Yes	Primary gas main	Swale is recommended
Weston St at Windsor Lane	Kerb blisters	E: 6,500 NW: 3,600 SW: 890	Yes	Energy, sewer and water services all in close proximity	E side planter bed is a potential opportunity for a swale. Consider at DD stage. NW and SW blisters are <10 sqm, rain gardens are not recommended at this scale
Weston St at Channel St	Kerb blisters	NE: none NW: 4,200 SE: 6,000 SW: 5,200	Yes	Gas conflict. Energy and sewer in close proximity	Proposed blisters are <10 sqm, rain gardens are not recommended at this scale.
Weston St at southern end	Kerb blisters	NW: 400 SE: none	No	Energy and gas conflicts	Stormwater treatment not recommended
Hercules Street near Consett St	Reduced roadway width and wider verges	NW: 680 NE: 730 SE: 340 SW: 1,130	Yes	Energy and gas conflicts	Swales are recommended
Terrace Road near Hercules Street	Kerb blisters	9,000	No	Gas, water, NBN conflicts	Stormwater treatment not recommended
Terrace Rd/Ewart St	New planting behind existing kerb	380	Yes	Major energy cables	Stormwater treatment not recommended
Ewart St/Ness Ave	Modification of existing planters	NW: 5,800 SW: 720 SE: 490	Converters only	NBN, gas, water conflicts	Swales are recommended
Ness Ave at Balfour St	Kerb blisters	N: 290 S: none	No	NBN, gas conflicts; water in close proximity	Stormwater treatment not recommended
Ness Ave at Tennyson St	Kerb blisters	N: 2,300 SE: 380 SW: none	No	Gas, sewer, water	North side is a potential opportunity for a swale. Consider at DD stage.
Ness Ave at Garnet St	Kerb blisters	NE: 560 NW: 460 SE: none	Not on E side. Unknown on W side	NE side has gas, water, comms. NW side relatively unconstrained	Rain garden is not recommended due to steep slope
Garnet St at Tennent Pde	Kerb blister	10,900	Unknown	Water, comms. Gas in close proximity	Potential opportunity for rain garden, but undersized for

Location	Proposed works	Catchment areas (sqm)	Underground drainage	Underground service constraints	Recommendation
					catchment. Would need to treat low flows only and protect from high flows. Consider at DD stage.
Riverside Cres	Kerb blister	3,300	No	Gas conflict. Energy in close proximity	Potential opportunity for swale. Consider at DD stage.

8 LIGHT RAIL CORRIDOR INTERFACE

Parts of the GreenWay are proposed within the existing light rail corridor, and at these locations, the requirements of rail infrastructure owners and the light rail operator are crucial considerations

8.1 LOCATIONS

Works are proposed within the existing Inner West Light Rail Corridor at the following locations:

- Hercules Street open space
- Elevated path from Hercules Street to Constitution Road
- Link between Johnson Park and Weston Street
- Lewisham West

This section considers the light rail corridor requirements and how they should be accommodated in the design of the GreenWay.

8.2 DESIGN PRINCIPLES

In these locations, land that is currently within the rail corridor would become publicly accessible, and management responsibilities would change. In these locations there is a need to establish a new boundary between the GreenWay corridor and the Inner West Light Rail corridor.

Within these areas, approvals will need to be sought as follows:

- The use of any rail land outside of the current bushcare licences needs agreement from RailCorp (being the land owner).
- Any areas licenced to TfNSW for the light rail would require a sub-licence from TfNSW to Council and requires separate negotiation.
- Works within the light rail corridor would also require approval from Transdev (light rail operator) as this may affect safety, day to day operation and maintenance activities.

These stakeholders have outlined their key concerns at the Master Plan stage, and will need to be satisfied that:

- **The rail corridor is safely secured from public access**. Trackside fencing is required along the rail corridor boundary.
- **Vegetation is planned and managed in line with relevant standards**. There are standards for vegetation management in proximity to overhead power lines, and overhead wiring (above the track).
- **Access is maintained to existing assets**: each of the land and asset owners will need access to their assets within the GreenWay and light rail corridors. They will want to check that access remains satisfactory to carry out maintenance tasks.

Each of these stakeholders will also need to be satisfied that the GreenWay does not impact on their assets, add a maintenance burden for them, or contravene other relevant guidelines and standards.

8.3 GUIDELINES AND STANDARDS

8.3.1 RAIL CORRIDOR BOUNDARY FENCING

The proposed corridor definition principles are set out in the “Central Missing Links Corridor Definition Principles” 15 September 2017 (Appendix D). as follows:

- A nominal **3.5 m** Infrastructure Service Requirement zone is proposed for the dedicated Permanent Light Rail Corridor (PLRC). The trackside fence will be located a nominal 3.5 m from the track centreline.
- Where other track side infrastructure exists outside the nominal Infrastructure Service Requirement zone the trackside fence will be deviated to provide a minimum **0.5 m** clearance

between the fence and the closest face of the other infrastructure.

- Where tracks are located in fill (at the top of a batter) the same principles as set out for on grade track sections will apply unless the batter is slope is deemed unsafe for access by landscape maintenance staff.
- Where tracks are in cutting (at the bottom of a batter) the trackside fence will typically be at the top of the cutting and set back a minimum of 1 m from the batter edge to prevent users falling down the batter.
- Where the active transport link is located at the corridor boundary, the boundary fence will be removed in line with the Active Transport Links on the Rail Corridor, unless it is a boundary with a private property.
- As set out in the *Active Transport Links on the Rail Corridor* standard, the minimum requirement for any fencing would be a 1.8 m high chain-link fabric fence along the full length of the active transport link. This standard is consistent with the RMS Bicycle Guidelines.
- Site specific access requirements to and around rail infrastructure will be determined with relevant agencies during the design process.

8.3.2 VEGETATION

Tree planting and other vegetation needs to take into account the location of existing infrastructure.

There are specific requirements for vegetation management in proximity to overhead power lines and overhead wiring. The relevant standards are:

- For vegetation clearances near overhead wiring equipment refer to T HR EL 08011 ST *Overhead Wiring Maintenance Standard*
- For vegetation clearances for HV aerial electrical equipment refer to T HR EL 10006 ST HV Aerial Line Maintenance Standard, which in turn refers to ISSC 3 Guide for the Management of Vegetation in the Vicinity of Electricity Assets
- A new Draft Tree Management Plan was also published by Sydney Trains in August 2018 (NSW Government 2018).

There is overhead wiring (OHW) above the tracks along the extent of the light rail corridor. In proximity to OHW, vegetation shall be maintained and controlled so that it is not within the following clearance envelopes:

- **3 m** from live exposed 1500 V dc equipment
- **1.5 m** from overhead wiring structures and guys, and dead OHW conductors

Vegetation that has been assessed to be at risk of falling into the OHW shall also be removed, even if it is located outside of the clearance envelopes specified above.

There is a 33 kV high voltage (HV) aerial transmission line within the light rail corridor between Constitution Road and Jack Shanahan Reserve. In proximity to HV aerial electrical equipment, vegetation clearances are dependent on the voltage, the conductor type, the span length and the position within the span. Clearance requirements are summarised below from the ISSC 3 document. Note that span lengths between Constitution Road and Jack Shanahan Reserve range from 90 to 160 m; clearance requirements in Table 12 apply to 100-200 m spans.

Table 12: Vegetation clearance requirements for 33 kV overhead lines (100-200 m spans)

Conductor type	Clearance profile	Portion of span	Clearance required (m)
Steel	All directions from any conductor	First and last 1/6th	1.5
		Middle 2/3rds	2.5
Bare conductors (not including steel)	All directions from any conductor	First and last 1/6th	3.0
		Middle 2/3rds	4.0

In addition to all the specific requirements above, the 2018 Draft Tree Management Plan (NSW Government 2018) recommends that in the vicinity of the electrical network:

- Low-growing species with a mature height of less than 3 m have been recommended
- Any species with a mature height over 3 m should be planted at least 10 m from power lines or at a distance equal to the mature height of the tree, whichever is greater

8.3.3 UNDERGROUND SERVICES WITHIN THE CORRIDOOR

Underground services exist within the rail corridor and prior to the commencement of any excavation work or earthwork, an underground services search must be undertaken.

All excavation and earthworks carried out on RailCorp property or within 5 metres of RailCorp's services shall be carried out in accordance with the Guide SMS-06-GD-2066 Managing Construction Hazards and Section Excavation and earth works near or in the vicinity of cables of the Guide SMS-06-GD-0268 Working Around Electrical Equipment. An excavation workplan must be prepared in accidence with Sydney

Trains requirements (SMS-06-FM-4376 Excavation Work Plan).

For excavation work in the Rail Corridor, a SMS-06-FM-0384 Services Search Request form is to be completed and emailed to the District Services Search Coordinator, Asset Management Group.

Where excavation or earth works is within 3m of RailCorp buried power cables, or cables in ducts, galvanised steel troughing (GST), ground line troughing (GLT), or cable pits, the Maintenance Engineer Electrical shall be contacted.

8.4 DESIGN CONSIDERATIONS

Site-specific design considerations are listed in Table 13. Site-specific comments from Sydney Trains and Transdev, have been included in Table 13 and specific responses made.

Additional general comments and responses are listed in Table 14.

Table 13: Site-specific design considerations where works are proposed in the rail corridor

Site	Key considerations in the concept design	Specific comments from Sydney Trains and Transdev (from Master Plan stage)	Concept design responses
Lewisham West	– Relocated light rail boundary fencing has been proposed on either side of the corridor with minimum 3.9m clearance from the centre of the tracks. – Electrical cables in GST and signal box has been accommodated within light rail corridor boundary fencing – Where electrical infrastructure is underground, no works are proposed and the area has been earmarked for planting only with grasses	Item 3.01 (wetland proposed at Lewisham West)– construction of wetland may not be possible as this would be located above Sydney Trains 33kV buried cable requires access.	Buried cables have been shown on concept design drawings and an area shown over these cables which would be planted only with low grasses, to allow for maintenance access. No earthworks or wetland construction is proposed above these cables. Refer EN-04-04.
		Item 3.02 – community garden may not be possible until contamination situation is known	Community garden is not included in the GreenWay construction scope. Wherever it is located, future garden may need to be built from raised beds with suitable imported soil.
		Item 3.03 - construction of bush track and stair may not be possible as this would be located above Sydney Trains 33kV buried cable, which requires access	Track and stair are now proposed to be accommodated within private property, as part of new development adjacent to the rail corridor. Refer LD-CD-208b
		Item 3.08 (dog off leash area) – this area forms part of the light rail corridor – any relocation would require agreement from TfNSW and Transdev	Proposed fenceline relocation is shown on concept design plans for discussion. Refer LD-CD-108, 208a, 208b
Link between Weston Street and Davis Street	– Proposed path alignment clashes with a transformer. Relocation is proposed. – Between Weston Street and Davis Street, there will be limited clearance to an existing signal box. In this location the path will be elevated with a balustrade	In regard to the DAVIS STREET CROSSING, a relocation to light rail signal box will be required	The proposed path has been designed to avoid the signal box (though there will be only a small buffer to the path). Refer to EN-02-01 Relocation of the adjacent transformer is currently under investigation by specialist electrical engineer.
Link between Davis Street and Johnson Park	– It is proposed to retain the existing fence between the light rail tracks and the bushcare site. – Maintenance access to the light rail corridor will be maintained off Terry Road		Refer to LD-CD-110 and LD-CD-210a
Elevated path from Constitution Road to	– Options to relocate overhead HV powerlines are currently being investigated by a specialist electrical design		Refer to structural report in Appendix B

Site	Key considerations in the concept design	Specific comments from Sydney Trains and Transdev (from Master Plan stage)	Concept design responses
Hercules Street	engineer – Concept design considers how the elevated path could be constructed without the need for access from the rail tracks themselves		
Hercules Street open space	– Options to relocate overhead HV powerlines are currently being investigated by a specialist electrical design engineer – New light rail boundary fencing is proposed along most of the corridor – It is proposed that the shared path also functions as a maintenance access path. Removable bollards have been shown at the southern end of Hercules Street to replace existing gate – As soil contamination is an expected, proposed cut and fill has been kept to a minimum – Proposed trees are shown offset from the rail tracks		Refer to drawings LD-CD-112 to LD-CD-312
Disused fork		Item 5.18 (disused fork) – this portion of land is under licence/agreement with ARTC and their agreement would be required	The Master Plan earmarked future works along the disused fork, but no works are proposed here as part of the current scope. It is understood that this space is currently being used for the Sydenham to Bankstown Metro project and therefore proposed GreenWay works will not be pursued until a later date

Table 14: General comments from Sydney Trains and Transdev (from Master Plan stage)

Comments	Concept design responses
Ensure any specified new plants won't require increased frequency of maintenance (if it needs to be undertaken by us depending on proximity from the new fence).	Guidelines for vegetation are summarised in this document (Section 8.3.2) to inform concept and detailed design.
Any tree planting shall take into account location of infrastructure (e.g. electrical) – new trees under overhead powerlines are to be avoided.	Guidelines for vegetation are summarised in this document (Section 8.3.2) to inform concept and detailed design.
Any new biodiversity off-set required as a result of the GreenWay need to be found/situated on land other than RailCorp land.	New biodiversity offset areas have not been proposed within RailCorp land

9 SERVICES

This section flags potential issues with services in the vicinity of proposed works. It also discusses the proposed relocation of the Sydney Trains overhead HV cables between Constitution Road and Jack Shanahan Park

Table 15 below provides notes on services in the vicinity of proposed works, identifying known details on service types, depths and dimensions, potential issues, and proposed actions.

In the table, rows highlighted in orange are major services or services with known/high risk of conflict with proposed works. In these cases, field location and discussion with service authorities is recommended to facilitate detailed design. Rows highlighted in yellow are minor services with lower risks of conflict. These will need to be located to facilitate construction.

In most cases, service conflicts are likely to be avoidable, but buried services will need to be located to confirm their locations and depths, so that detailed design can work around existing infrastructure. It will also be necessary to confirm any easements, construction offset requirements or procedures which need to be followed during construction. Therefore the table below also flags many sites for service location.

9.1 RECOMMENDED SITE INVESTIGATIONS

Particular sites where further investigation is essential to inform detailed design are:

- Bay Run at the western end of the Lilyfield Road bridge. Proposed elevated ramps will require foundations and there are significant energy and gas services in this area.
- Richard Murden Reserve, along path alignment. Lighting locations should be considered in relation to underground services, particularly where services run in line with path.
- At the northern end of Weston Street there are multiple services and works will need careful consideration to avoid conflict, particularly any stormwater drainage.
- In the rail corridor between the south end of Weston Street and the Davis Street tunnel, there are multiple electrical services including a Sydney Trains isolation transformer which will need to be relocated. The design of the relocation is subject to a separate design process.
- Downstream of Terry Street: details of existing stormwater system are required to finalise design of proposed stormwater capacity upgrade works. Other underground services also need checking in this area, as excavation is proposed.
- Constitution Road tunnel. Multiple services crossing Johnson Park immediately north of tunnel, within roadway at tunnel crossing, and Sydney Trains HV power pole and line to be relocated immediately south of tunnel.
- Within the Hercules Street open space, services need checking, particularly where cut/fill and/or structures are proposed.
- At the Terrace Street/Ewart Street intersection, proposed stormwater drainage works need to be informed by service locations.

9.2 RELOCATION OF 33 kV POWER LINES

Between Constitution Road and Jack Shanahan Park, there is an existing overhead 33 kV power line in the rail corridor. One pole location (immediately south of Constitution Road) directly conflicts with proposed path works.

At Hercules Street, if the tunnel proposed in the Master Plan is ever to go ahead, there is also a pole located in the southern footpath, which would also need to be relocated to allow the tunnel to go ahead.

Relocation of the overhead 33 kV power lines (either underground or into cable trays) would allow a better outcome in the proposed ecological restoration zone, by allowing more extensive revegetation (including trees, offset an appropriate distance from track overhead lines) and reducing ongoing disturbance from maintenance activities.

It is proposed to relocate the overhead line along its full extent, from Constitution Road to Jack Shanahan Reserve, into a GST on the eastern side of the light rail tracks. The existing aerial feeder would be retained south of Jack Shanahan Reserve. This work would be completed ahead of other works in the corridor and is subject to a separate design process.

9.3 RELOCATION OF WATER MAIN

Immediately south of Parramatta Road, there is a 500 mm water main that crosses the Hawthorne Canal stormwater channel. Relocation of this water main has been proposed to allow construction of the underpass under Parramatta Road. The water main would be realigned for a length of approximately 25 m, and would cross the channel approximately 15 m further south of Parramatta Road.

The water main relocation is discussed in the Water Services Co-ordinator's report (Warren Smith and Partners, 2019). It is also shown in the concept design drawings.

Note that an important design consideration for the relocated water main is the geotechnical conditions on the eastern side of the stormwater channel. Given the slope stability issues here, the concept design shows that the water main would be supported with a contiguous pile wall socketed into bedrock. This will require further design development to confirm details.

Construction access will also need to be considered. The pile wall to support the relocated water main could potentially be constructed either from the stormwater channel or from the concrete pad near the light rail access steps off Parramatta Road (or a combination of the two).

Table 15: Service locations, details and potential issues

LOCATION	SERVICE	ISSUE	PROPOSED ACTIONS	EXTRA NOTES
Iron Cove seawall and Bay Run path	Power	under path	Service location, minimal excavation/compaction. Locate foundations for ramps and other structures away from cables	2x TR 33kV, ?m cover, crosses under concrete/sandstone steps, ~0.76m cover under City-West Link 1x AUX, ~0.4m cover, under shared path at S seawall, then crosses beneath City-West Link power DBYD largely missing at N end
	Gas	under path	Service location, minimal excavation/compaction. Locate foundations for ramps and other structures away from gas mains	559mm dia 3500kPa ST under/behind concrete/sandstone steps, then crosses City-West Link and follows road around 250mm dia 1050kPa ST in N verge of Lilyfield bridge, under ped path then crosses ped and bike path SW into housing 75mm dia 210kPa NY ends in shared zone at UTS - we don't want to move valve boxes
	Stormwater	pipe outlets under path	Service location, minimal excavation/compaction	DBYD shows 4 outlet points, and some pits in exg path, so if we don't change levels we won't have to move new path must grade to exg low points
		pits in path near UTS	No level change so pits don't need moving	new path must grade to exg low points
	Comms	Survey file shows pits near path, but DBYD shows nothing	TBC	Comms info needs to be verified – survey issue

LOCATION	SERVICE	ISSUE	PROPOSED ACTIONS	EXTRA NOTES
Richard Murden Reserve	Gas	In some areas, path is in line with gas main (parallel to Hawthorne Pde on western side of reserve)	Service location, minimal excavation/compaction. Consider light locations	Major gas main (Jemena). 559 ST 3500 kPa
	Sewer	In line with path at southern end of reserve, also crossing northern end	Service location, minimal excavation/compaction. Consider light locations	Dimensions and depths are available on DBYD plans and this should be sufficient at DD stage.
	Power	Mid section of reserve	Service location, minimal excavation/compaction. Consider light locations	Likely to be related to existing lighting in reserve
Parramatta Road	Water – south side of Parramatta Rd	Water main crosses the stormwater channel immediately south of Parramatta Rd. Conflict with proposed underpass.	Relocation of water main to cross the stormwater channel approximately 15 m further south of Parramatta Road.	500 mm water main. Refer to Water Services Co-ordinator report (Warren Smith and Partners 2019) for further details.
	Water – 450 mm main, north side of road	Support beams are low under Parramatta Road and constrain headroom for underpass	Modification of the 450 mm water main has been proposed to remove support beams and replace with self-supporting pipe span	450 mm CICL
	Water – other mains under Parramatta Road	Two other water mains under Parramatta Road.	Confirm locations. Many services are visible where Parramatta Road crosses Hawthorne Canal. .	150 mm CICL 150 mm CICL
	Sewer	Sewer main over canal south of Parramatta Rd	Confirm locations. Provide temporary pumped bypass during works with reinstatement as new at completion of works.	225 mm VC
	Power	Energy cables under Parramatta Rd, on northern side	Confirm locations. Many services are visible where Parramatta Road crosses Hawthorne Canal.	Ausgrid, 3x distribution cables
	Gas	Disused gas main constrains headroom for underpass	Modification to smaller diameter self-supporting span under Parramatta Road, to improve headroom.	Existing man is 900 mm. Proposed 500 mm. (Refer to Appendix E – TLB Gas Main Options Report, 2018)
		Gas main under Parramatta Road, on northern side	Confirm locations. Many services are visible where Parramatta Road crosses Hawthorne Canal.	110 mm NY 210 kPa
	Comms	Cables under Parramatta Road, on southern side	Confirm locations. Many services are visible where Parramatta Road crosses Hawthorne Canal. Potential opportunity to adjust services/supporting beams to increase clearance.	Including optic fibre
Gadigal Reserve	Water	Two major water mains along western side of stormwater channel	Service location, minimal excavation/compaction. Consider water main locations in design of footings for new bridge across stormwater channel and works for nature observation area.	2 x 500mm dia water mains. Refer to Water Services Coordinator report (Warren Smith and Partners 2019) for further details.
	Sewer	Underground on western side of stormwater channel	Service location, minimal excavation/compaction. Consider in design of footings for new bridge across stormwater channel and works for nature observation area.	225 mm VC

LOCATION	SERVICE	ISSUE	PROPOSED ACTIONS	EXTRA NOTES
	Sewer	Elevated sewer with piers in close proximity to proposed path	Retain minimum 0.5m clearance to each pier.	
	Power	Two cables across channel and underground either side, under MWR bridge and close to Longport St	Service location, minimal excavation/compaction	One or both of these may belong to Sydney Trains - TBC
	Comms	Cables pass through Gadigal Reserve between rear of #9 Haig Ave and Barker St	Service location, minimal excavation/compaction	Appears to be multiple cables in a Telstra leased conduit
	Stormwater	Breaking out channel wall to facilitate vehicle access ramp and path footing integral with canal wall	Confirm modification requirements with Sydney Water.	
Longport Street	Gas	Main under Longport St; tunnel will need to pass under	Service location, minimal excavation/compaction. Jacked tunnel likely here.	75mm NY distribution main, 210 kPa
	Electricity	Multiple cables under Longport Street, both northern and southern side of street. Tunnel will need to pass under	Service location, minimal excavation/compaction. Jacked tunnel likely here.	North side of Longport Street: Distribution cables including 6 direct buried cables, 2x150 AC ducts. South side of Longport Street: Transmission cables in three ducts: 2x150 GI, 1x100 GI, 0.9 m cover.
	Water – under road	Water main under Longport St; tunnel will need to pass under	Service location, minimal excavation/compatction. Jacked tunnel likely here.	300 mm CICL
	Water – immediately north of road	Elevated path will pass over above-ground water main immediately north of Longport St	Proposed pier locations avoid water main. Consider maintenance access in design.	1200 mm CICL
	Stormwater	Channel passes deep under proposed tunnel	Confirm any service protection requirements with Sydney Water	
Lewisham West: dog off leash area	TfNSW Light Rail infrastructure	Underground HV cables	Service location, minimal excavation/compaction, only grasses to be planted	Design has specifically accommodated this set of buried cables
	Stormwater	trunk main adjacent E boundary	Service location, minimal excavation/compaction	Sizing/depths unknown, but generally the trunk mains are deep on this site
		trunk mains at northern end	Service location, minimal excavation/compaction	1200mm dia RCP, 990mm x 990mm concrete culvert
	Sewer	adjacent E boundary at northern end	Service location, minimal excavation/compaction	150mm dia PVC - 375mm dia RC encased, ~6.27m deep at E boundary, maybe built as part of Luna
		at northern end	Service location, minimal excavation/compaction	150mm dia VC (will be old/brittle), ~3.7m cover at E boundary
Lewisham West: wetland area	TfNSW Light Rail infrastructure	Underground HV cables	Service location, minimal excavation/compaction, only grasses to be planted	Design has specifically accommodated this set of buried cables

LOCATION	SERVICE	ISSUE	PROPOSED ACTIONS	EXTRA NOTES
	Sewer	Sewer main under proposed wetland	Service location, confirm Sydney Water requirements. Wetland construction over sewer should be feasible providing adequate cover is retained.	150 mm VC
Lewisham West: west of light rail	Sewer	Manhole + main passing under path near Longport St tunnel	Service location, minimal excavation/compaction	150 mm VC
		South end- pit proud of existing surface level	Either lower pit or raise surface levels. Discuss with Sydney Water	50 mm VC – noted as Disused on Sydney Water plans. Flagged for DD stage so potential to modify can be discussed with Sydney Water
	TfNSW Light Rail infrastructure	Underground cables, signal box	Locate boundary fence around existing infrastructure	
Weston St/Old Canterbury	Gas	Gas main along Old Canterbury Road in works area. Proposed stormwater needs to cross	Confirm levels to ensure proposed stormwater drainage works are feasible both in Old Canterbury Rd and Weston St	110 mm NY 210 kPa
		Gas main along Weston and under proposed swale	Service location, minimal excavation/compaction	559mm dia 3500kPa ST gas main along west side of Weston on unknown alignment at unknown depth
	Comms	Along Old Canterbury Road in works area	Ensure proposed stormwater drainage works are feasible	
	Water	Under proposed works area	Service location, minimal excavation/compaction	150 mm CICL
	Sewer	Under proposed works area		225 mm SGW
	Power	under new footpath, close to exg SEPG (Weston) and new blister/rain garden works	Service location, minimal excavation/compaction	2x HV, 2x AUX, 1x mains, ~0.6m cover
Weston St/Windsor Lane	Stormwater	Raised platform construction	trafficable JP lids currently in road, will need to be raised to platform level	
	Gas	Blister construction	Service location, minimal excavation/compaction	559mm dia 3500kPa ST gas main along west side of Weston on unknown alignment at unknown depth
		Raised platform construction	gas valve box currently in road, will need to be raised to platform level	559mm dia 3500kPa ST gas main along west side of Weston on unknown alignment at unknown depth
	Sewer	Under planter bed on E side of street	Service location, minimal excavation/compaction	525 mm VC
	Power	under raised platform	Service location, minimal excavation/compaction	1x TR, 1x AUX, ~0.8m cover
Weston St/Channel St	Gas	under new blister and footpath	Service location, minimal excavation/compaction	210kPa

LOCATION	SERVICE	ISSUE	PROPOSED ACTIONS	EXTRA NOTES
	Power	under new footpath/platform crossing	Service location, minimal excavation/compaction	1x TR, 1x AUX, ~0.9m cover
Weston St E/Weston St W	Gas	under new blister and speed hump	Service location, minimal excavation/compaction	559mm dia 3500kPa ST gas main along west side of Weston on unknown alignment at unknown depth
	Power	under new blisters	Service location, minimal excavation/compaction	2x TR, 3x AUX, ~0.9m cover
		under new footpath	Service location, minimal excavation/compaction	2x HV, 3x AUX, ~0.6m cover
Davis St tunnel	Power	above tunnel along Davis St	Service location, consult with AusGrid re options to manage this service during tunnel construction.	lighting cable, probably no deeper than 0.9m
	TfNSW Light Rail infrastructure	Isolation transformer clashes with path alignment	Relocation	It is proposed to relocate the isolation transformer. This work would be complete ahead of other works in the corridor and is subject to a separate design process.
		Signal box in close proximity to tunnel alignment	Temporary protection works during construction; seek exemption from minimum offset recommended elsewhere	
Davis Street to Johnson Park	Sewer	Within rail corridor	Service location, minimal excavation/compaction	
	Water	Crossing site at Terry Road	Service location, minimal excavation/compaction	Water main is located very close to proposed new stormwater pit. Design may need to be modified
	Stormwater	New drainage connection to Sydney Water stormwater system may be required	Service location, design around existing infrastructure. Engage Water Services Co-ordinator for new connection to channel downstream of Terry Rd	Need to confirm details of existing infrastructure in order to design proposed works.
Constitution Rd tunnel	Stormwater	pipes under new footpath	Building over Sydney Water major storm water. Engage Water Service Coordinator to determine protection measures.	300mm dia RCP likely under gas line, plus connects in to trunk mains beneath Lewisham stn, so definitely >0.7m 1x 1350mm dia RCP Crown approx. 2.71m below proposed path and 1x 1200mm dia RCP approx.. 2.95m below proposed path Both major stormwater pipes located with CCTV and sonde.
	Gas	pipes under Constitution Rd	Service location, consult with Jemena re options to manage this service during tunnel construction.	32mm dia 210kPa NY ends right near edge of tunnel - may require relocation. 150mm dia 1050kPa ST runs under Constitution Rd protect high pressure line in place and minimise vibration.
	Power	under new footpath	will very likely require relocation to allow retaining wall construction	1x LV, ~0.4m cover – park lighting cable
	Sydney Trains HV power	pole above tunnel + overhead aerials	Relocation	It is proposed to relocate the overhead aerials and poles. This work would be complete ahead of other works in the corridor and is subject to a separate design process.

LOCATION	SERVICE	ISSUE	PROPOSED ACTIONS	EXTRA NOTES
	Water	pipe under Constitution Rd	Service location, engage Water Services Co-ordinator to determine how to manage this service during tunnel construction	200mm dia CICL (may be old/brittle) – provide rider main during works with reinstatement as new at completion of works.
	Comms	under Constitution Rd	Service location, consult with Telstra to determine how to manage this service during tunnel construction	Telstra, may require relocation.
Elevated path between Constitution Rd and Hercules St	Sydney Trains HV power	overhead aerials above and to W side of path	Relocation	It is proposed to relocate the overhead aerials and poles. This work would be complete ahead of other works in the corridor and is subject to a separate design process.
	TfNSW Light Rail infrastructure	Cable tray between light rail tracks and proposed path	Temporary protection works during construction	
Hercules St ped/cycle crossing	Gas	along new kerbline, under crossing (stormwater has been designed to avoid conflict)	Service location, minimal excavation/compaction	32mm dia 210kPa NY
	Power	under new footpath	Service location, minimal excavation/compaction	1x LV, ~0.5m cover
Hercules Street open space	Power	adjacent NW edge of S wetland	Service location, minimal excavation/compaction, only grasses to be planted	6x TR, 4x AUX, ~1.1m cover
	Stormwater	along N and E edge of N upper wetland. Diversion proposed.	Field verify locations	300mm dia RCP along N edge, 450mm dia RCP along E edge
		Along creekline. Some structures potentially missing from survey	Field verify locations	450mm dia RCP?
		Under lower wetland. Some details missing from survey	Field verify locations	1650mm dia RCP along W and N edges, 600mm dia RCP connecting in near NW corner of wetland
	Sewer	along part of creekline between wetlands	Service location, minimal excavation/compaction	225mm dia VC (will be old/brittle), ~2m cover
Hercules St near Terrace Rd	Power	under new footpath	Service location, minimal excavation/compaction	2x HV, 2x AUX, 1x LV, ~0.6m cover
Terrace St/Ewart St	Power	under new footpath and planting	Service location, minimal excavation/compaction	4x HV, 2x AUX, ?m cover
	Water	under new speed hump	Service location, minimal excavation/compaction	750mm CICL (may be old/brittle)
		under new kerbline. Stormwater drainage has been designed to avoid conflict	Service location, minimal excavation/compaction	100mm CICL (may be old/brittle)
	Gas	under new blisters and footpath	Service location, minimal excavation/compaction	75mm dia 210kPa NY
	Comms	under new footpath	Service location, minimal excavation/compaction	NBN duct and UECOMM cable
Ness Ave/Ewart St	Gas	under new footpath, rain garden and blister	Service location, minimal excavation/compaction	559mm dia 3500kPa ST gas main along (centre of?) Ness on unknown alignment at unknown depth

LOCATION	SERVICE	ISSUE	PROPOSED ACTIONS	EXTRA NOTES
		under new footpath and blister	Service location, minimal excavation/compaction	75mm dia 210kPa NY
	Water	under new footpath	Service location, minimal excavation/compaction	100mm CICL (may be old/brittle)
	Sewer	under BB	Service location, minimal excavation/compaction	150mm VC, 1m deep - brittle
Ness Ave/Balfour St	Gas	under new median island	Service location, minimal excavation/compaction	559mm dia 3500kPa ST gas main along (centre of?) Ness on unknown alignment at unknown depth
		under new blisters	Service location, minimal excavation/compaction	75mm dia and 32mm dia 210kPa NY
	Water	under new speed hump	Service location, minimal excavation/compaction	100mm CICL (may be old/brittle)
	Comms	under new blisters and footpath	Service location, minimal excavation/compaction	NBN
Ness Ave/Tennyson St	Gas	under new blisters and pram ramps	Service location, minimal excavation/compaction	75mm dia and 32mm dia 210kPa NY
		under speed hump	Service location, minimal excavation/compaction	559mm dia 3500kPa ST gas main along (centre of?) Ness/Tennyson on unknown alignment at unknown depth
	Water	under new speed hump and very close to new kerbline at SE blister	Service location, minimal excavation/compaction	100mm dia CICL (may be old/brittle) exg valve box/es very close to S corner of blister - we should miss this so ok
		under new blister and pram ramp	Service location, minimal excavation/compaction	100mm CICL (may be old/brittle)
Ness Ave/Garnet St	Gas	under new blisters	Service location, minimal excavation/compaction	75mm dia 210kPa NY?
	Water	under new speed hump	Service location, minimal excavation/compaction	unknown
		under new blister kerbline	Service location, minimal excavation/compaction	100mm CICL (may be old/brittle) exg valve box/es very close to kerbline of N blister - we should miss this so ok
	Comms	under new blisters	Service location, minimal excavation/compaction	NBN
	Power	under new S blister kerbline	Service location, minimal excavation/compaction	2x HV, ~0.5m cover
Garnet St/Tennent Pde	Gas	under new blister	Service location, minimal excavation/compaction	75mm dia 210kPa NY?
	Water	under new blister	Service location, minimal excavation/compaction	100mm CICL (may be old/brittle)
	Comms	under new blister kerbline	Service location, minimal excavation/compaction	NBN
Riverside Crescent/Wardell Rd	Gas	under new blister	Service location, minimal excavation/compaction	559mm dia 3500kPa ST gas main along west side of Weston on unknown alignment at unknown depth
	Power	under new footpath	Service location, minimal excavation/compaction	1x HV, 3x AUX, ~0.6m cover

10 REFERENCES

AS 1428.1:2009 – Design for Access and Mobility

AS 5100:2017 Bridge Design

Austroads "Guide to Road Design Part 6A – Paths for Walking and Cycling" (2017)

Austroads Research Report "Cycling on Higher Speed Roads" (2012)

Covich, C and Makim, P 2015 "From sea wall to sea life: implementing seawalls that support intertidal biodiversity" NSW Coastal Conference 2015

CROW "Design Manual for Bicycle Traffic" (2016 edition)

Karimbla Construction Services 2014, stormwater drainage plans for 78-90 Old Canterbury Road

Knights and McAuley 2020 Technical Options Report – Gadigal Reserve to Parramatta Road. Final draft, July 2020.

NSW Government 2016 ISSC 3 "Guide for the Management of Vegetation in the Vicinity of Electricity Assets"

NSW Government 2018 "Tree Management Plan" Draft for Consultation, August 2018

Queensland Government Crime Prevention Through Environmental Design Guidelines (2007)

RailCorp Guide SMS-06-GD-2066 Managing Construction Hazards and Section Excavation

RailCorp Guide SMS-06-GD-0268 Working Around Electrical Equipment

RMS' Technical Direction TTD 2016/001 "Design and implementation of shared zones including provision for parking"

RMS Technical Direction TDT 2013/05, "Continuous Footpath Treatments", August 2013

Sydney Trains SMS-06-FM-4376 Excavation Work Plan

Thanks for 30 website (thanksfor30.com.au) accessed October 2018

Transport for NSW T HR EL 08011 ST "Overhead Wiring Maintenance Standard"

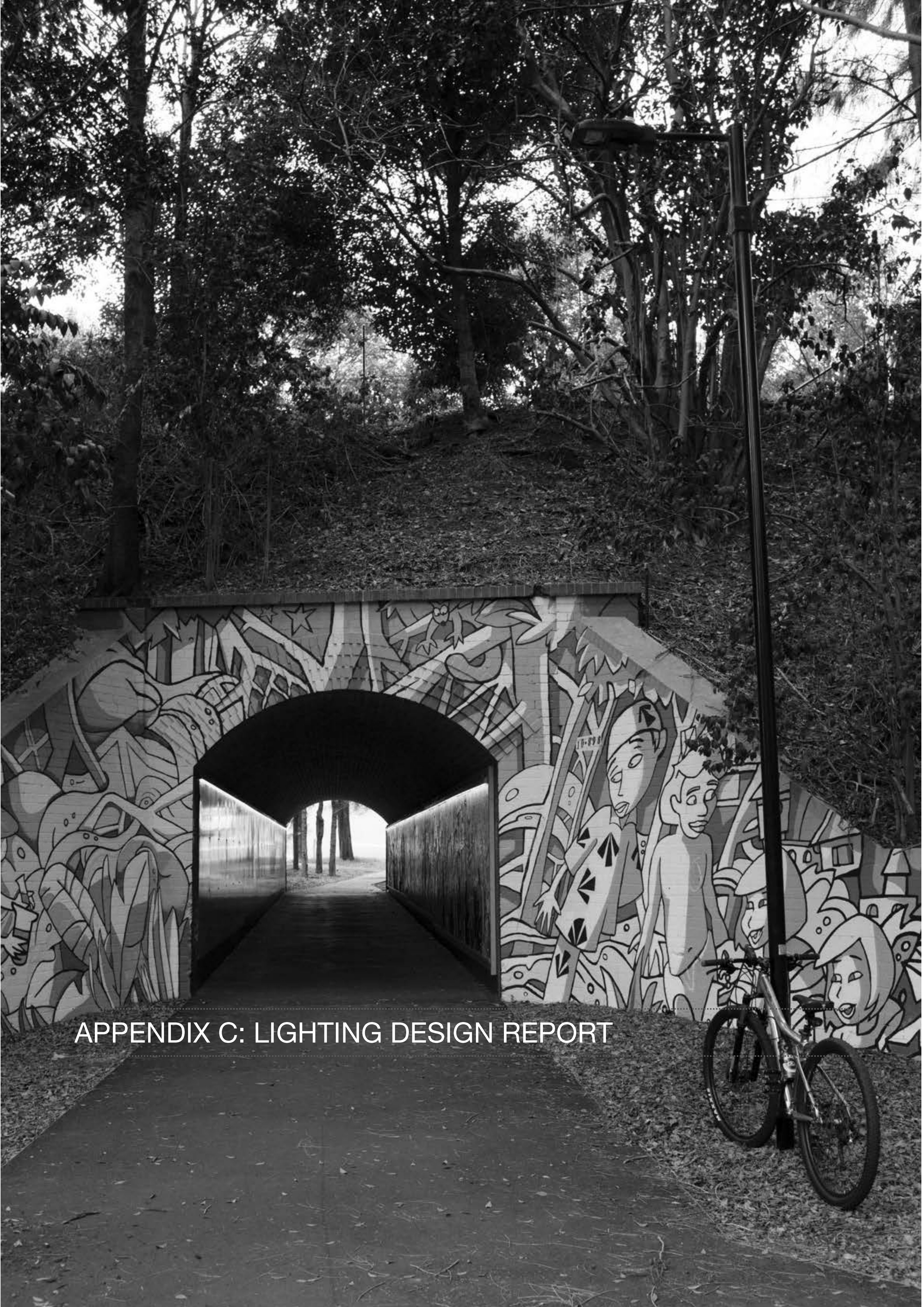
Transport for NSW T HR EL 10006 ST "HV Aerial Line Maintenance Standard"

Warren Smith and Partners 2019 Technical Note – Greenway Cycleway design assessment on existing Sydney Water assets. Revision 1, 17/04/2019.

Watson, P., Lord, D. and Snelgrove, C. 2009 "Sydney Harbour Sea Level Rise Vulnerability Studies"

APPENDIX A: TRAFFIC ENGINEERING ADVICE

APPENDIX B: STRUCTURAL ENGINEERING ADVICE



APPENDIX C: LIGHTING DESIGN REPORT

APPENDIX D: LIGHT RAIL CORRIDOR PRINCIPLES

APPENDIX E: SERVICE REPORTS UNDER PARRAMATTA RD