

Redfern North Eveleigh Crossing

The crossing should provide a connection across the obstacle created by the rail corridor, save time, encourage permeability, and be a convenient, safe and accessible piece of infrastructure.

Objective

Released under GIPA Act 2009 (NSW)

Objectives

What characteristics should the crossing have?



Connect the North and South Eveleigh communities



Provide local permeability across the rail corridor



Safe



Comfortable



Convenient



Provide time savings for pedestrians and cyclists



Accessible



Sustainable



Sympathetic to the industrial heritage of the area



Connection to Country



Value for Money



Facilitate an Innovation and Collaboration precinct

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Site Attributes

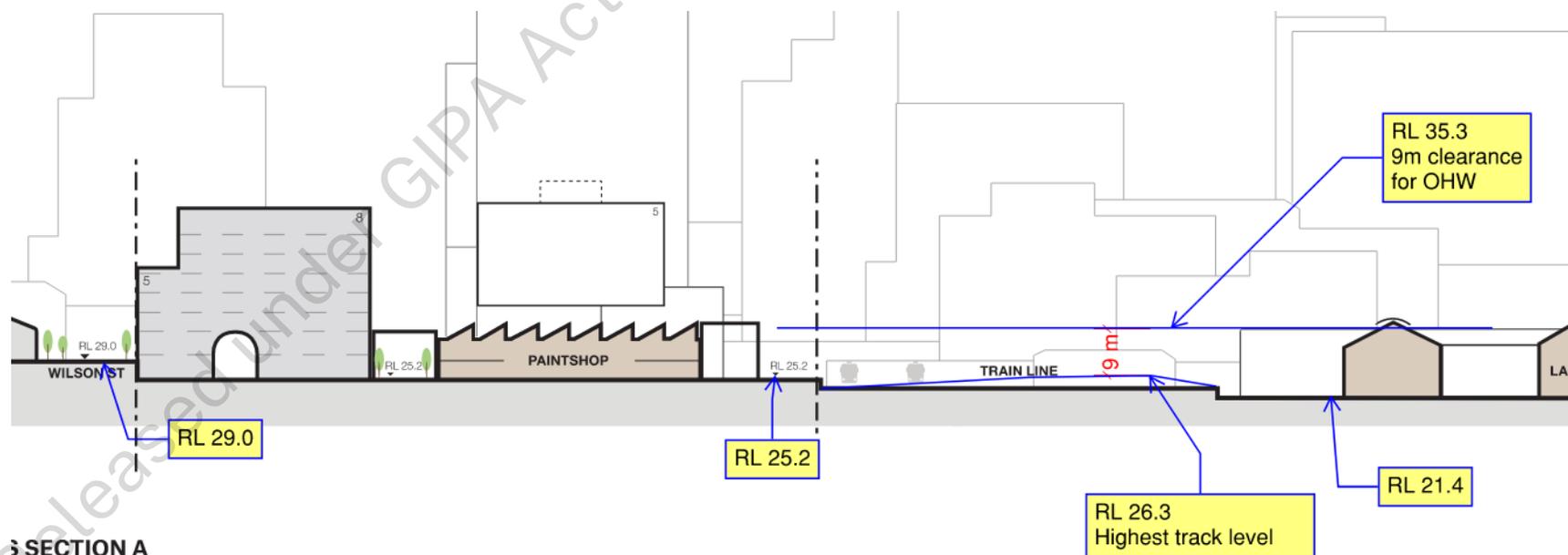
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Constraints - Topography

The site is on a declining landform, there is a significant elevation change along the crossing alignment

The Topography across the site, and necessary vertical clearances to the rail corridor, results in:

- 10.8m rise/fall from north landing to ground
- 7m rise/fall from north landing to Wilson Street
- 14.6m rise/fall from south landing to ground



Constraints – Rail

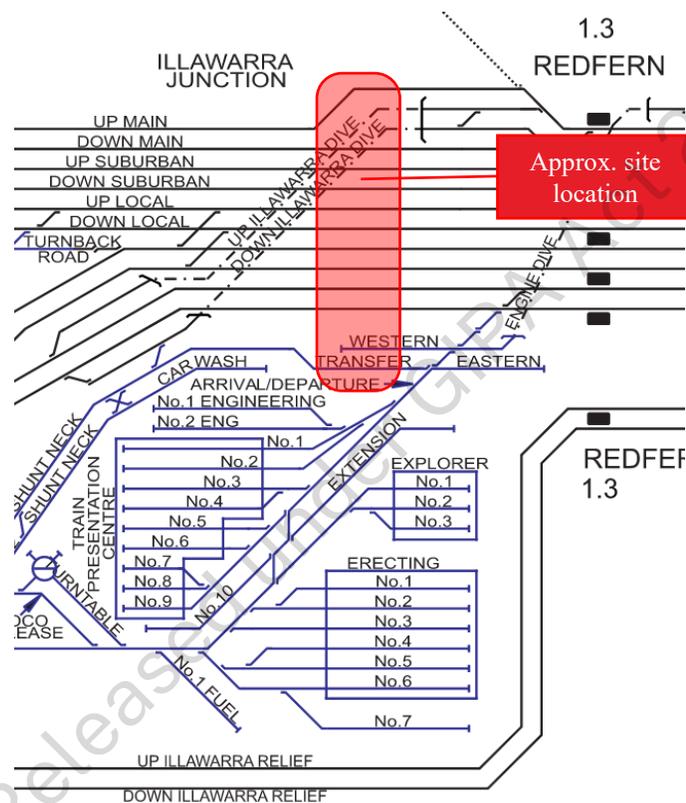
The length of the crossing results in permanent works within the Rail Corridor

The rail corridor at this location is a key network artery that:

- Provides principal access to Central Station
- Is located within the Suburban and Intercity Train Maintenance Centre

Constraints in this area require the crossing:

- Construction activities align with the possession configurations.
- Utilises staged construction, with activities to be delivered in 48hr blocks.



Indicative crossing zone in red on the Metropolitan Network Diagram V3 TfNSW Config Diagram (2010)

Constraints – Rail

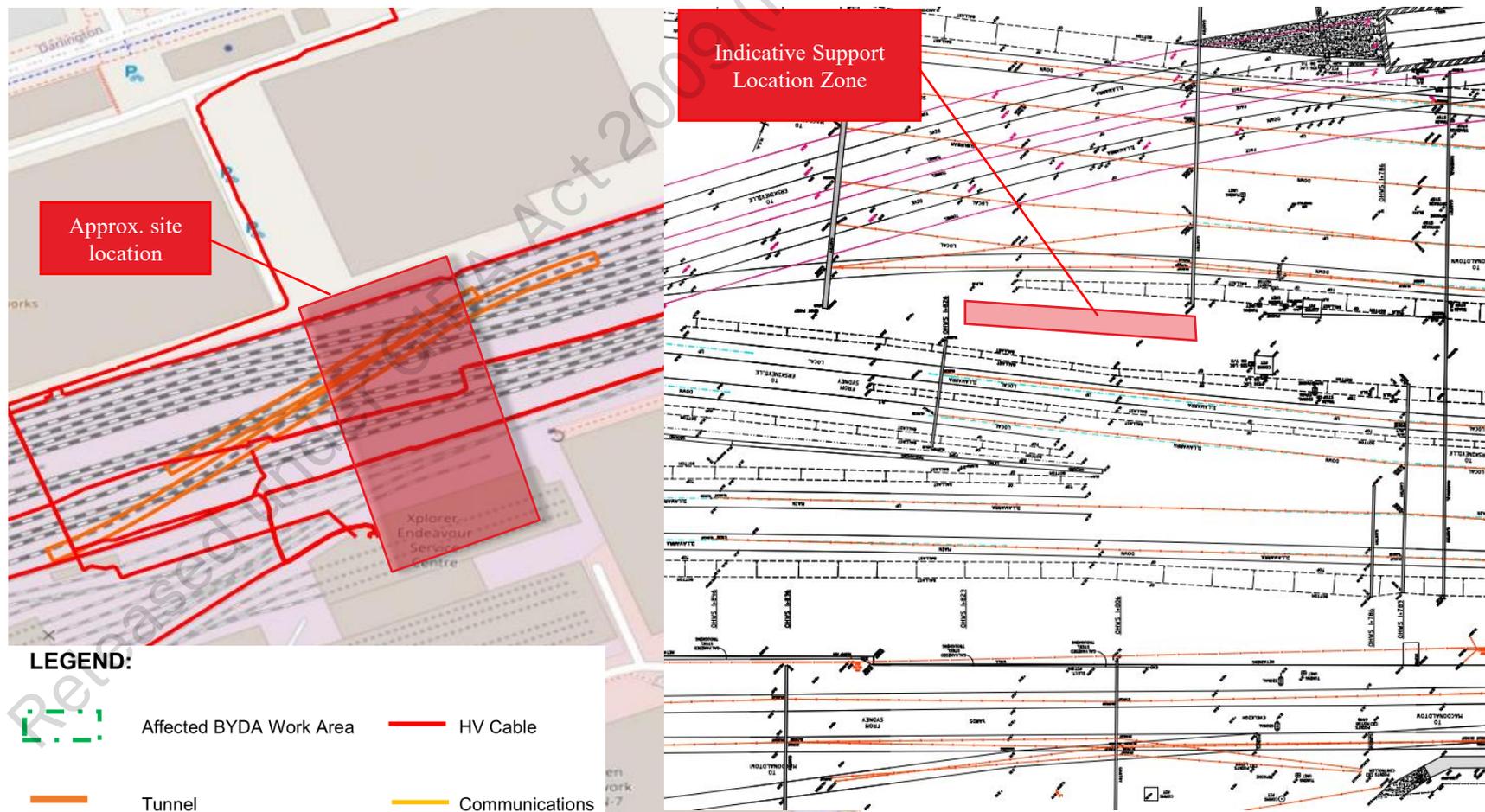
Significant built infrastructure exists within the study area

Active assets in the area include:

- HV cables
- Signaling & communication infrastructure
- Illawarra Dives (Tunnel)
- Redundant Workman's subway
- Overhead Wiring and Elevated Signal Gantries
- Potential for other underground services

Constraints in the area include:

- Works generally should not be within 5 metre radius of any electrical, communication assets, and within 25 metres of any other TfNSW tunnel.
- 9m vertical clearance over Rail Corridor



Constraints - Third Party Utilities

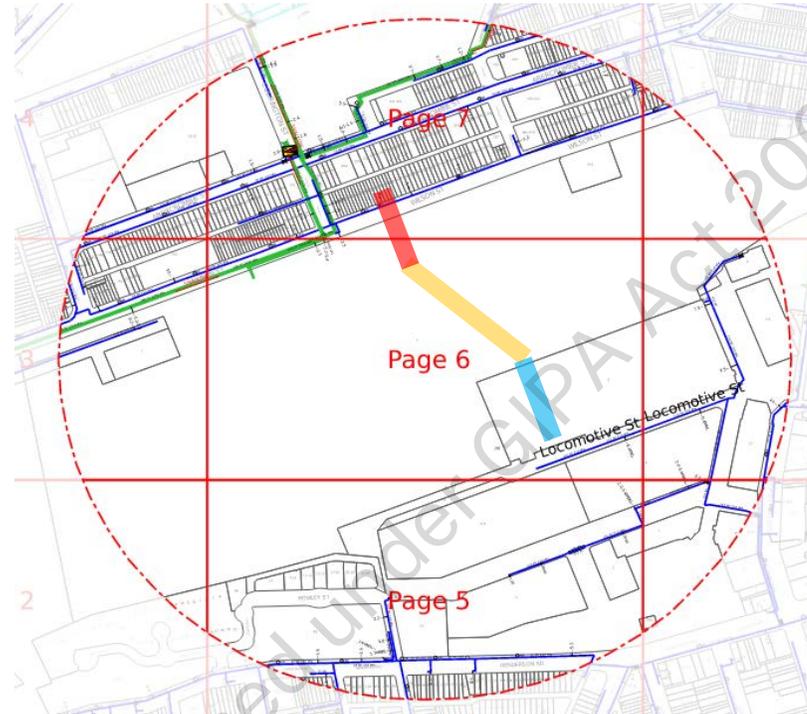
Existing utilities exist at both boundaries of the crossing

Currently identified assets include:

- Jemena
- Sydney Water
- Ausgrid
- City of Sydney
- NBN
- Potential for other underground services

Constraints include:

- Works may not be undertaken within the clearance set by the asset owner



Jemena DBYD

- Traverser
- Potential Crossing location
- Corridor between the Locomotive Workshop and the LES Building

- 210kPa Medium Pressure gas main
- 300kPa Medium Pressure gas main
- 400kPa Medium Pressure gas main
- 1050kPa High Pressure gas main

Sydney Water DBYD

- Sewer property connection point
With chainage to downstream maintenance hole.
- Sewer concrete encased section
- Sewer Rehabilitation
- Sewer terminal maintenance shaft
- Stormwater gully
- Stormwater maintenance hole
- Watermain – potable drinking water
With size type text.
- Disconnected watermain potable drinking water
This means the watermain has been disused but remains in the ground.
- Recycled watermain

Review of Previous Studies

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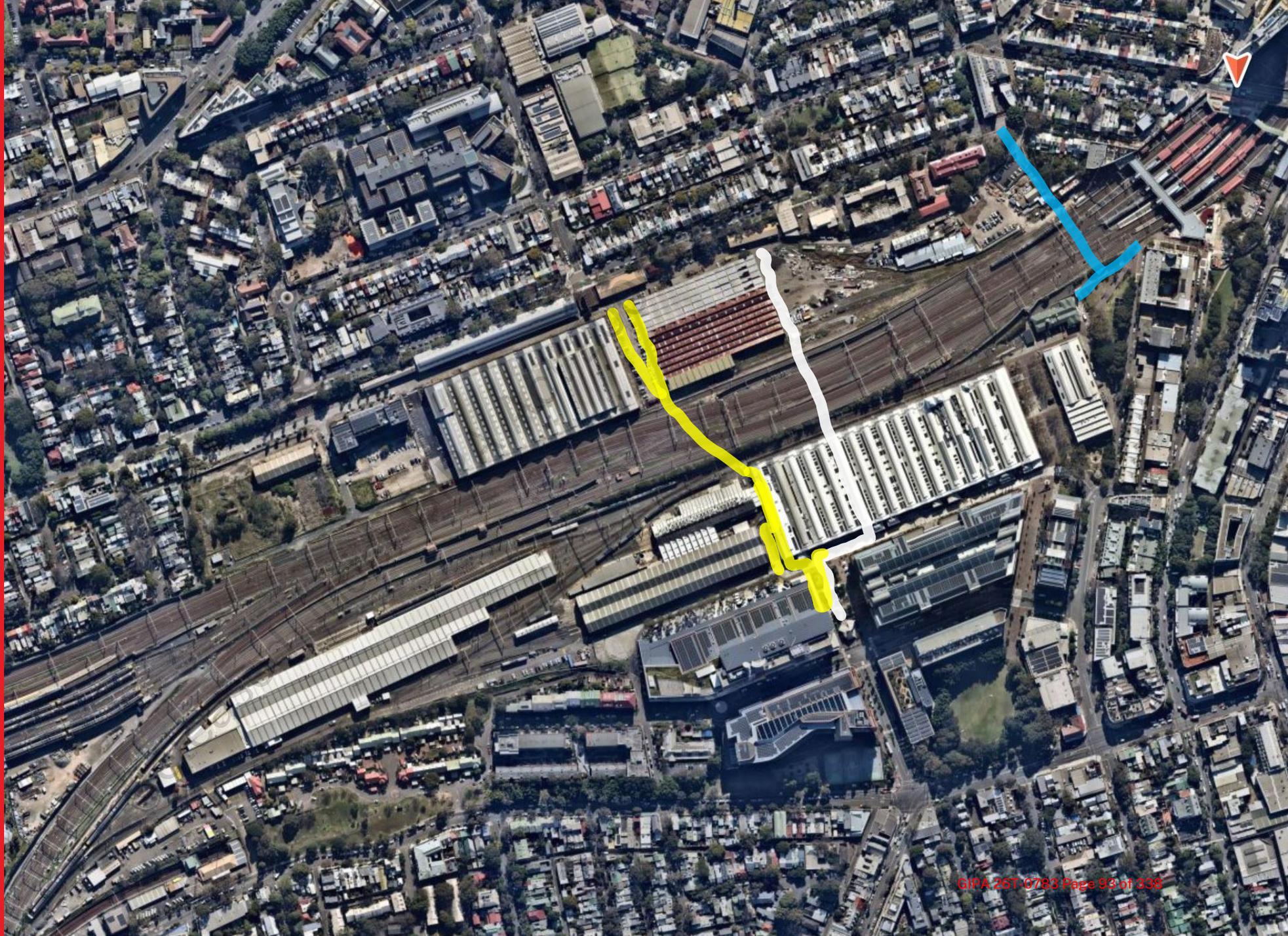
Study Areas & Alignments



Eveleigh Heritage Walk Report for
Redfern Waterloo Authority [2008]



Carriageworks to Australian
Technology Park – North-South
Pedestrian Link for *UrbanGrowth
NSW* [2017]

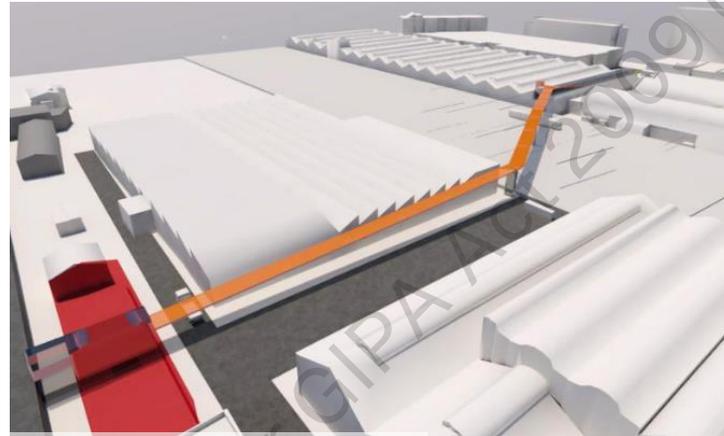


Previous studies

2008 and 2017 Studies for the Carriageworks to Australian Technology Park Pedestrian Link

Arup were previously commissioned to review the site constraints including constructability and develop sketches of bridge concepts for preliminary costing.

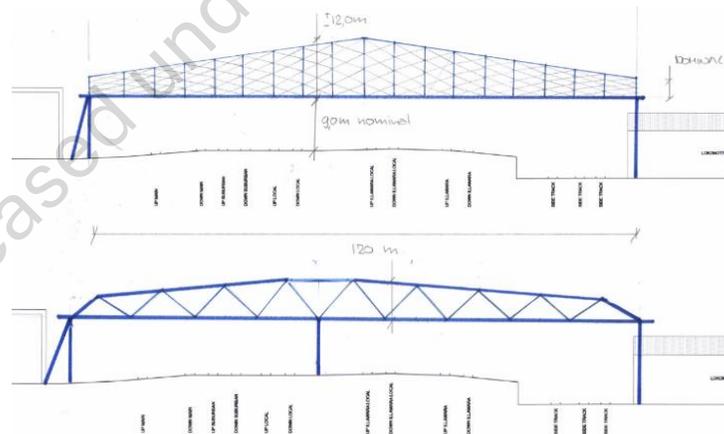
- The 2008 study favoured eastern alignments over the western alignments as the bridge length could be minimized (undertaken pre new Redfern Station crossing)
- The 2017 study examined bridge crossing along the western alignment, including structural forms and end connections



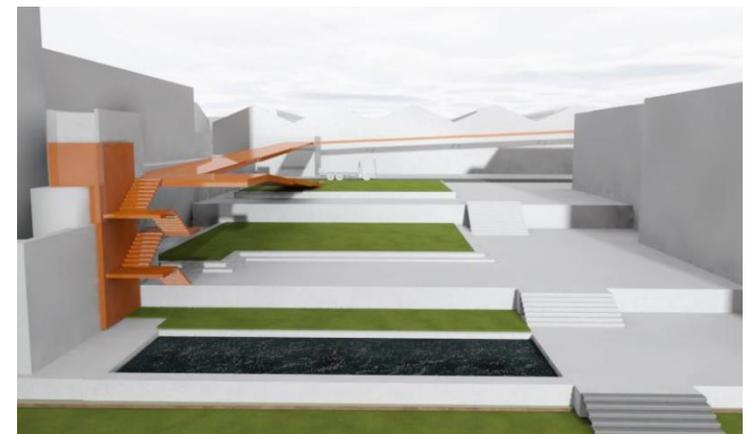
North landing to Wilson Street



South landing option in Locomotive Shed bay

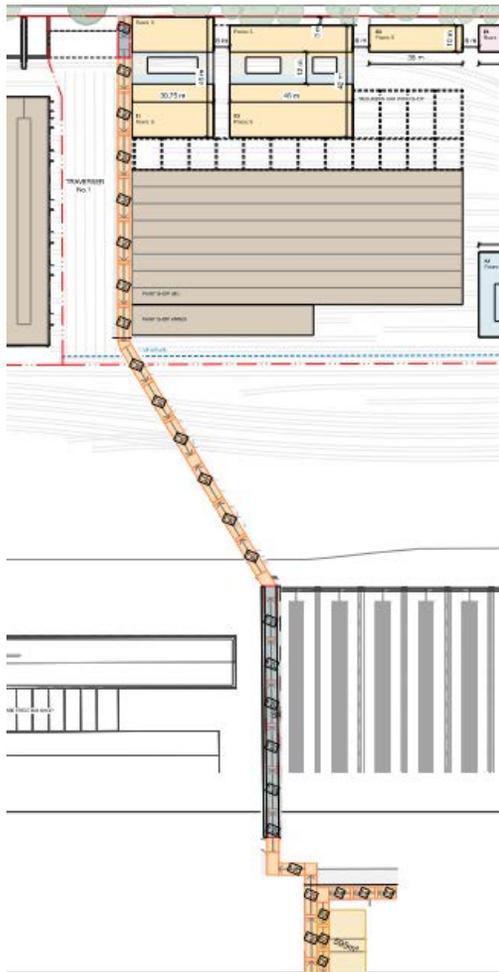


Truss options with pier, clear spans are ~50-120m

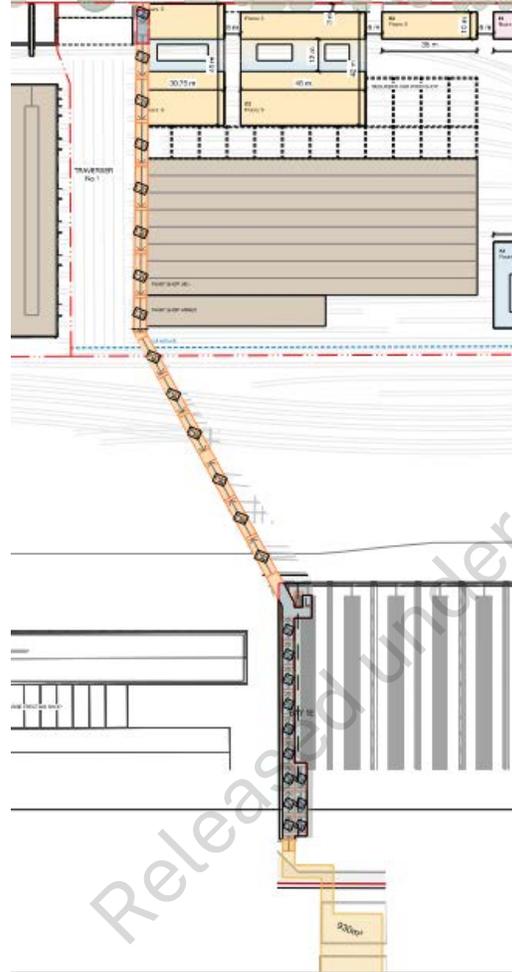


South landing option along village square (between Channel 7 and CBA)

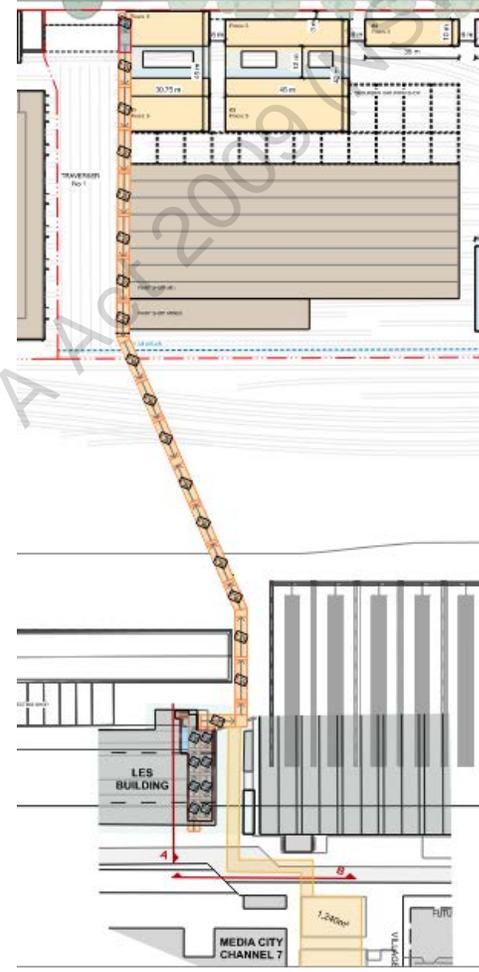
Previous studies



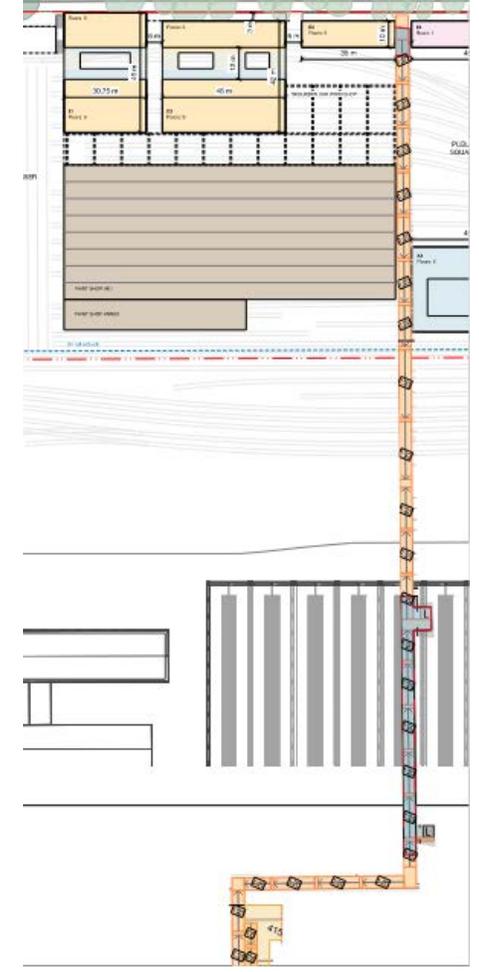
Option 1A



Option 1B



Option 1C



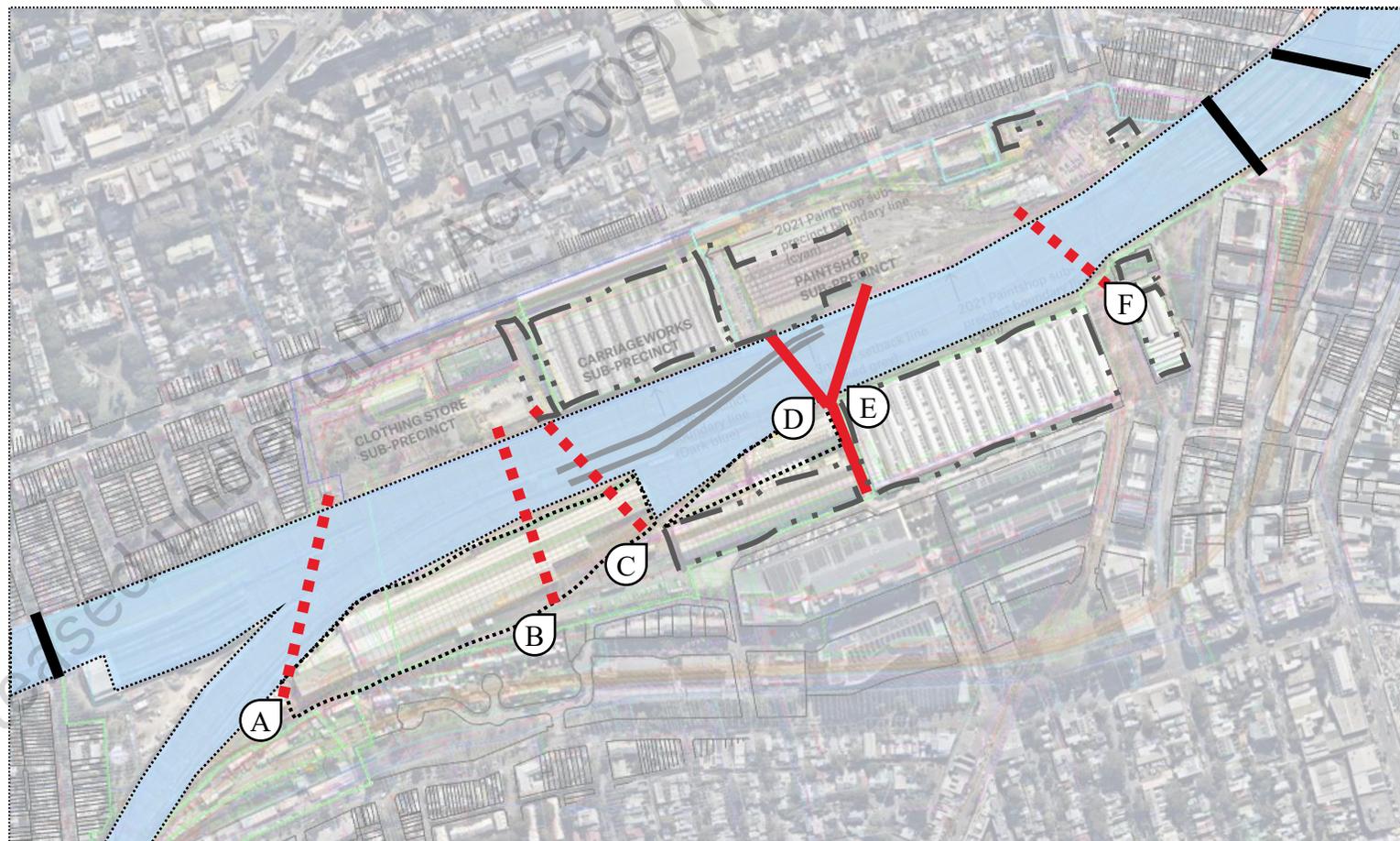
Option 4

Above ground alignment options – Where should it go?

The Carriageworks to LES connection provides the best outcome for permeability. i.e. Alignments D and E.

- Study alignment
- - - - - Alternate alignments
- Existing connection
- ~ ~ ~ ~ ~ Minimum 10m clearance height above rail corridor; HV cable, drainage at rail corridor
- ~ ~ ~ ~ ~ Illawarra Dive (tunnel)
- - - - - Eveleigh Maintenance Centre
- . - . - Heritage

- Alignment, and crossing type should,
- Comply with the rail corridor physical and operational constraints.
 - Mitigate approvals from Sydney Trains for any design or construction activity.

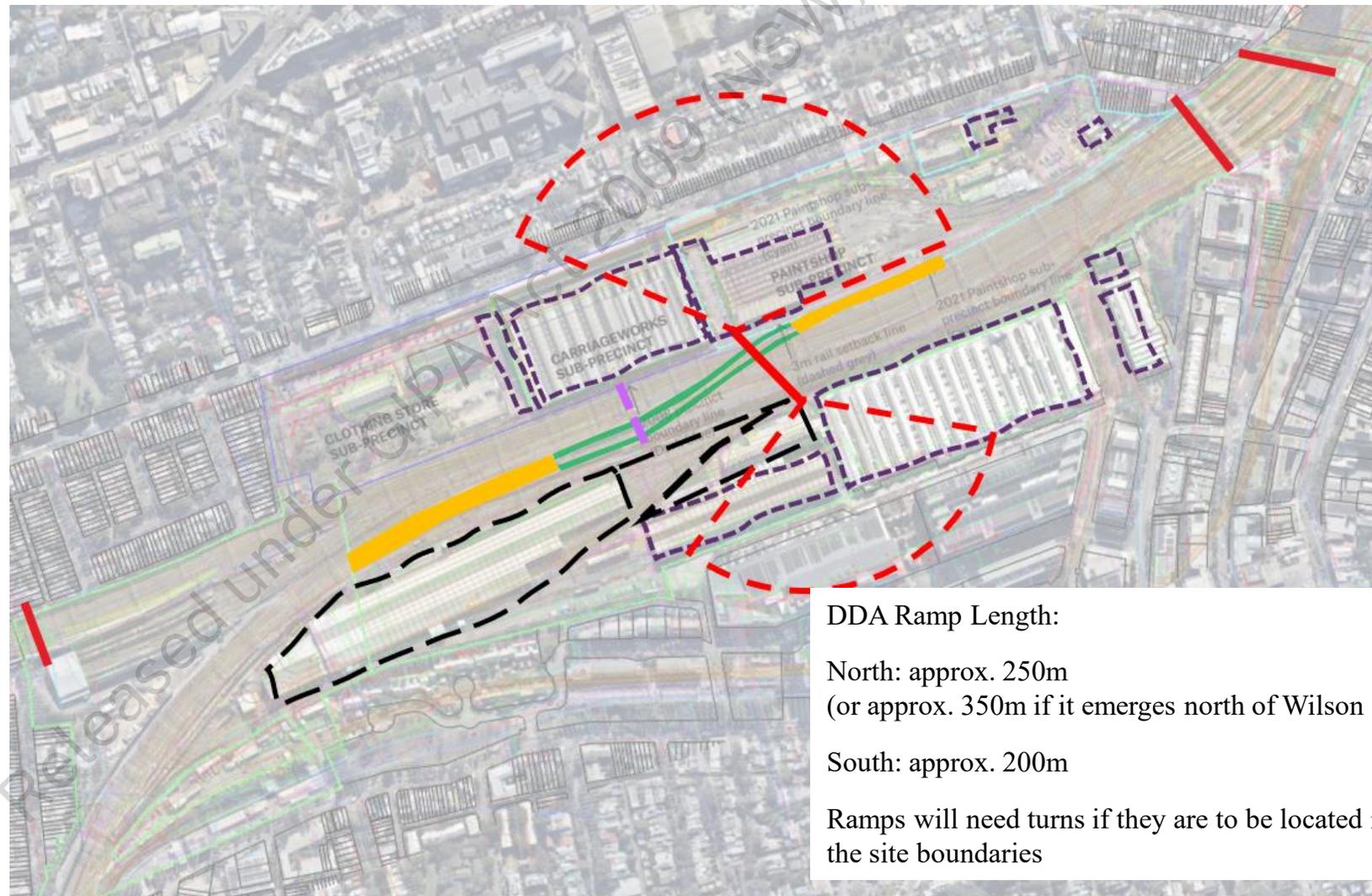


Bridge siting map

Above ground alignment options – Where should it go?

Existing Underground Structures

-  Study alignment below rail corridor as per preferred bridge alignment (tunnel invert 12 to 15m below existing track level)
-  DDA ramp length as radius (1 in 20 grade with landings) extending from tunnel invert
-  Illawarra Dive
-  Illawarra Tunnels (invert max 8m below existing track level)
-  Eveleigh maintenance tunnel
-  Pedestrian crossings
-  Eveleigh Maintenance Centre
-  Heritage



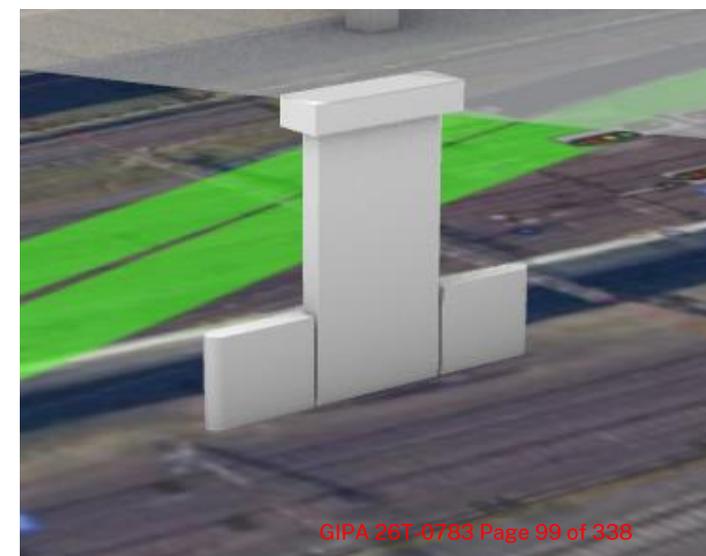
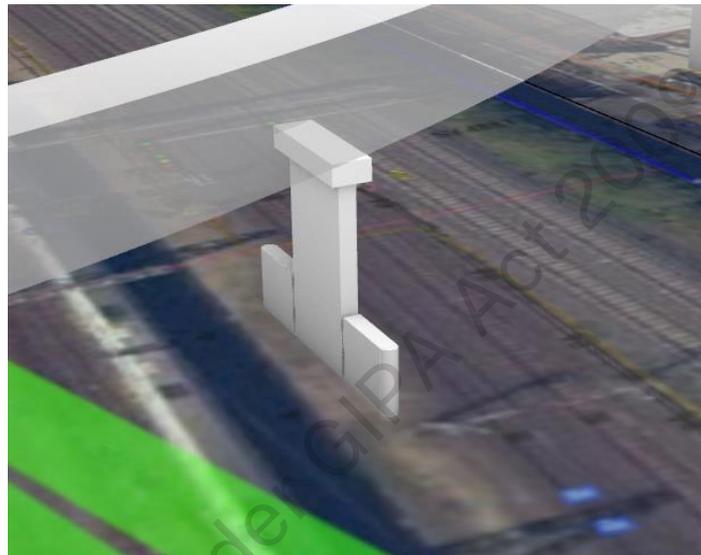
Crossing Options – Above ground crossing

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Bridge – Central Support

A pier in the rail corridor is required and needs Sydney Trains approval.

- A pier is required, otherwise the structure becomes very large.
- Eastern crossing precluded as pier location is severely constrained.
- Construction must occur during a rail shut down (i.e., possession)
- This section of the rail corridor is a key artery close to Central Station
- Design and construction requirements for the Sydney Trains corridor are very stringent and required their approval
- Approvals and possession pose a program and cost risk.
- Pier has been positioned to clear existing HV and Signalling services within the rail corridor.



Bridge – Elevator & Stairs

North & South - Constrained locations

- Main spans approx. dimensions - 45m (Nth), 55m (Sth)
- Southern Approach approx. lengths - 50m, 47m, 35m
- Northern stair tower approx. height – 10.5m (~4 stories)
- Southern abutment approx. height - 15m (~5 stories)
- Southern stair piers & tower approx. height – 10m, 10m & 7m



Bridge – Elevator & Stairs

Northern Elevator and Stair located in constrained site

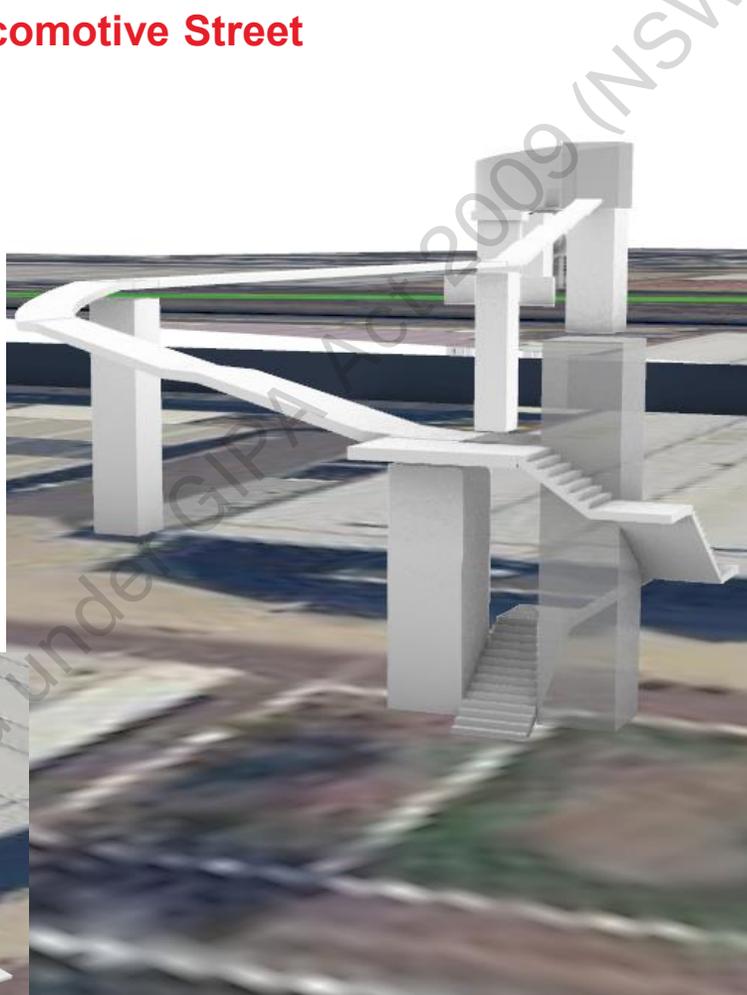
- Abutment, stairs and elevator are to be positioned clear of
 - Heritage Listed Traverser (where it is currently parked)
 - Heritage Listed Paint Shop Annex (with no demolition of the Annex)
 - Local Drainage (including connection at Traverser)



Bridge – Elevator & Stairs

Southern Elevator and Stairs located off Locomotive Street

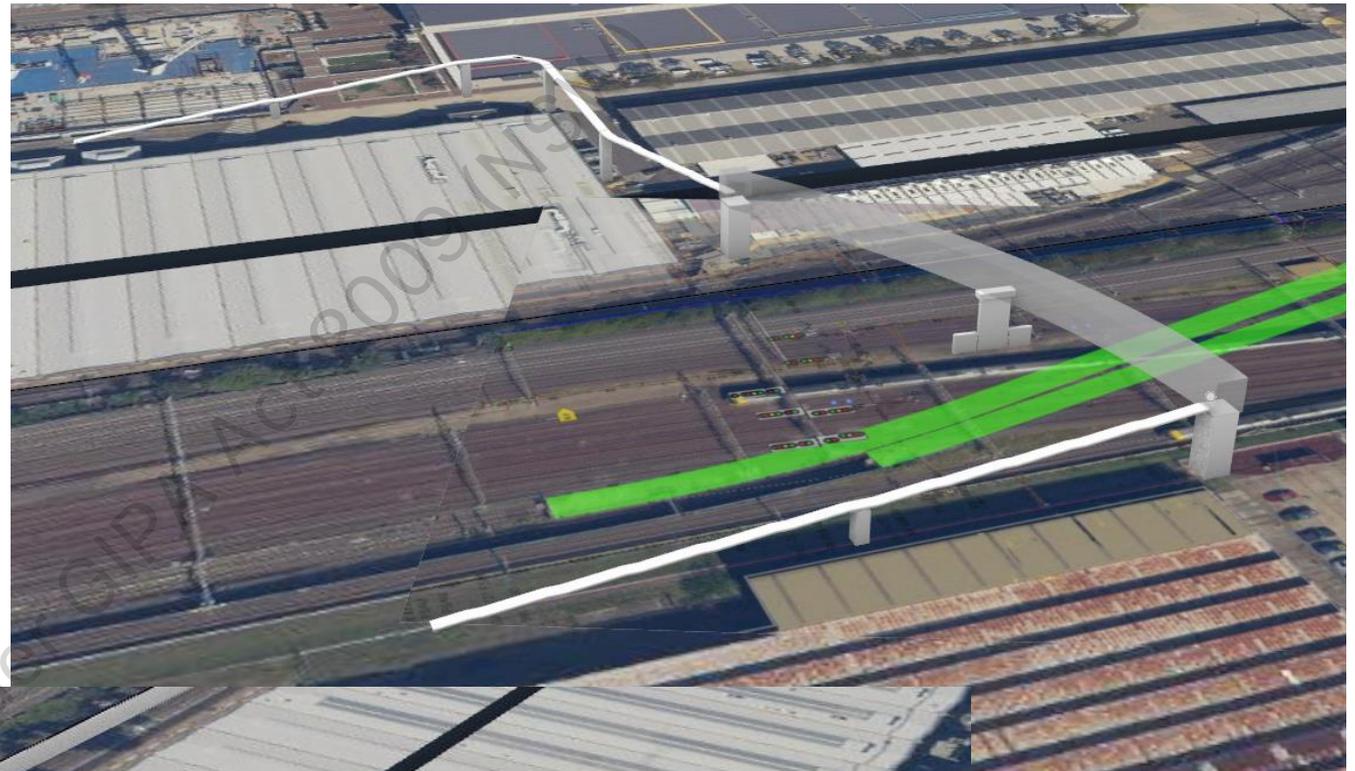
- Stairs and landings located in Davy Street Park
- An extended deck is required to span over the live maintenance facility which requires 24hr access. Access is also to be maintained to facilities including Large Erecting Shop
- Significant engagement and approvals would be required from Sydney Trains.
- Opportunity grade ramp down (subject to approval) to minimise stair tower height
- Public (pedestrian & vehicular) access to be maintained to Locomotive Street



Bridge – Ramps

Ramp connections to innovation precincts

- Main spans unchanged
- Northern Approach approx. lengths 55m, 55m
- Southern Approach approx. lengths - 50m, 47m, 25m, 40m, 40m



Superstructure – General Forms

The images presented are generic bridge forms to suggest the typologies of possible bridges.

Throughout the iterative design process, the design principles for the site would be integrated with structurally feasible solutions.

It should be noted that all bridge forms must satisfy minimum clearance of 9m above railway track to avoid clashing with the existing OHW and signal gantries.

A **truss form** was identified as the least obtrusive form and was taken forward for the purpose of this study. Weathering steel could be used for the construction, which would also eliminate maintenance requirements for painting.

Truss



Tied Arch



Cable-Stayed



Height of spanning structure	5 – 6.5m tall	10 – 15m tall (from tying chord to highest point at arch)	Pylon height ~25 – 30m
Span length	50 – 65m	50 – 65m	100 – 130m
Other requirements	Central pier required	Central pier required	Need space for the back stay (image shown is a comparatively compact arrangement) Needs very tall pylons of ~ 25-30m high

Considered further
Form is sympathetic to industrial character of the surrounds.

Crossing Options - Below ground options

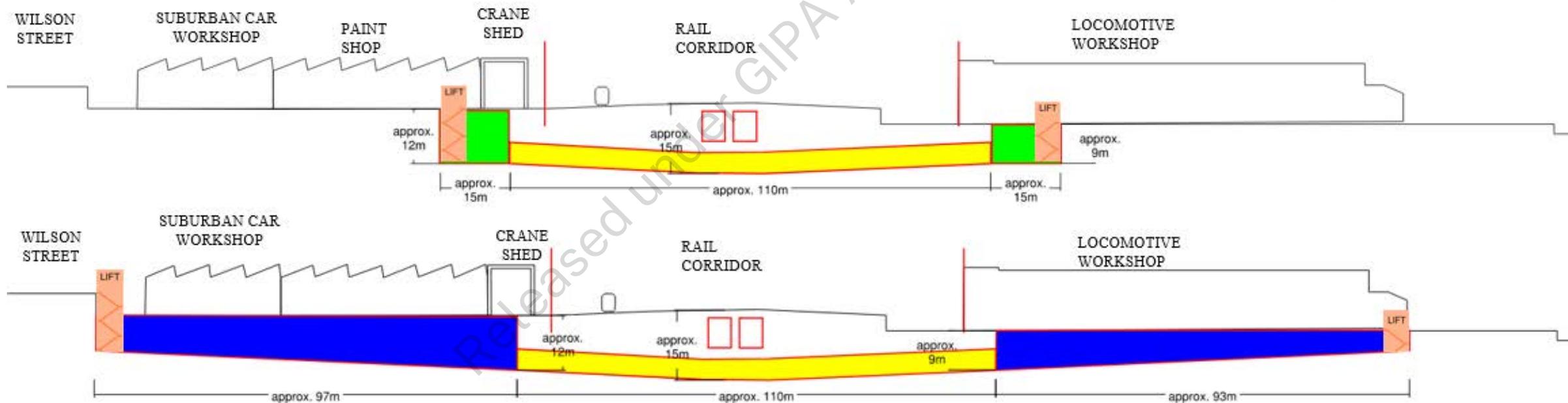
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Tunnel Vertical Alignment

Site Topography and clearances are a major constraint to the access arrangements.

- The substantial level difference means that any ramps will be very long.
- Lifts and stairs are more appropriate at tunnel entries.
- There are limited to no locations to stage/launch tunnelling works

- Existing Illawarra tunnels
- ▭ Mined tunnel – approximate length 110 m
- ▭ Cut and cover dive structures
 - North dive – approx. length 97m
 - South dive – approx. length 93m
- ▭ Cut and cover access shaft – approximately 15m square



Crossing Options - Alternatives

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Crossing Options - Alternatives

Non-fixed link crossings available include Urban Cable Cars, Personal Rapid Transits/Monorails, Shuttle Buses, eScooters

Opportunities

- Minimise works within rail corridors (minimal infrastructure for Shuttle Bus/eScooters)
- Flexibility in the alignment (vertical and horizontal)
- RNE crossing could form part of a network

Risks

- Ongoing operating costs (inc. permanent staff)
- Operation can be weather dependant
- Bridge still required for Rail Corridor (PRT & Monorail)
- Low passenger throughput,
 - >2000pph (Urban Cable Car)
 - <1000pph (PRT) 5000+pph (Monorail)
- Require delivery/operating entity,
- eScooter public safety (collisions/accidents).

On Demand Shuttle, Sydney
(Credit: KeolisDowner)



Mi Teleférico urban cable car system,
La Paz, Bolivia (Credit: Getty Images)



(Credit: City of Hobart)

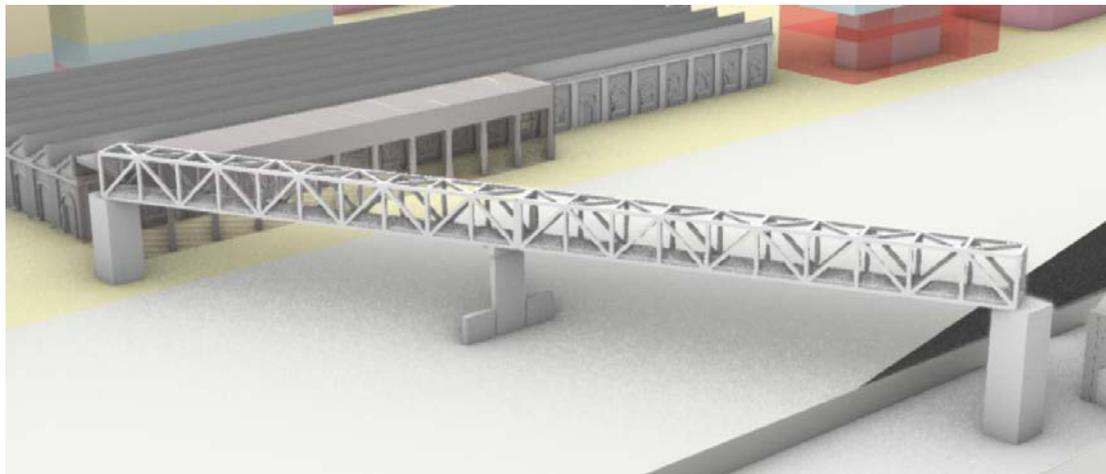


WeSPa Tsubakiyama Slopecar, Fukaura, Japan
(Credit: Wikipedia)

Conclusions and other issues to consider

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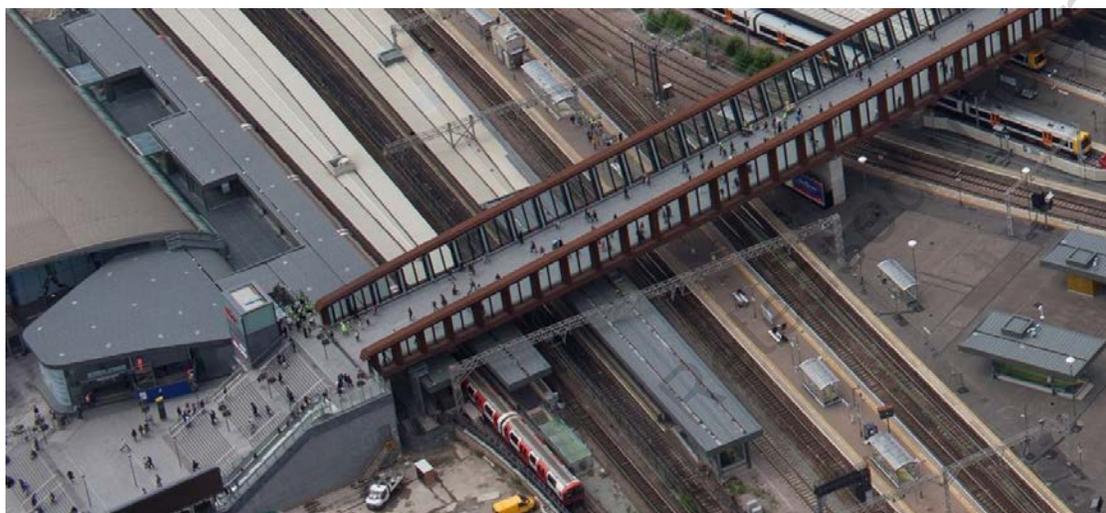
Benchmark Comparisons – Bridge Forms



2022 RNE STUDY



Breakfast Creek Green Bridge, Brisbane (exp 2024) (Credit: Brisbane City Council)



Stratford Town Centre Link (2010) London

(Credit: 5th Studio)



Kangaroo Point Bridge, Brisbane (exp 2023)

(Credit: Brisbane City Council)

Benchmark Comparisons – Bridge Forms

	2022 STUDY	Stratford Town Centre Link	Breakfast Creek Green	Kangaroo Point
Type and location	Multi-span Through Truss. Crossing railway corridor	Continuous Through Truss. Crossing railway corridor (& station)	Single Span Arch. Crossing river	Cable stay with approach spans. Crossing river
Approx. dimensions	~110 x 5.5m	~130 x 12m	80 x 5m	470 x 6.8m
RNE site applicability		Constructed in constrained urban environment Launched to minimise lifting/cranage needs	Potential to span corridor. Would require temporary construction piers within Rail Corridor	Bridge stayed from central pier. Requires significant pier/pile cap in the middle of rail corridor.

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Conclusion

A detailed benefits assessment and business case is required.

	Connect the North and South Eveleigh communities			Accessible	
	Provide local permeability across the rail corridor			Sustainable	
	Safe			Sympathetic to the industrial heritage of the area	
	Comfortable			Connection to Country	
	Convenient			Value for Money	
	Provide time savings for pedestrians and cyclists			Facilitate an Innovation and Collaboration precinct	

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ARUP

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Redfern North Eveleigh Bridge

Feasibility Study

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Redfern North Eveleigh Bridge

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Objectives

What characteristics should the bridge have?



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Sympathetic to the industrial heritage of the area



Connection to Country



Value for Money

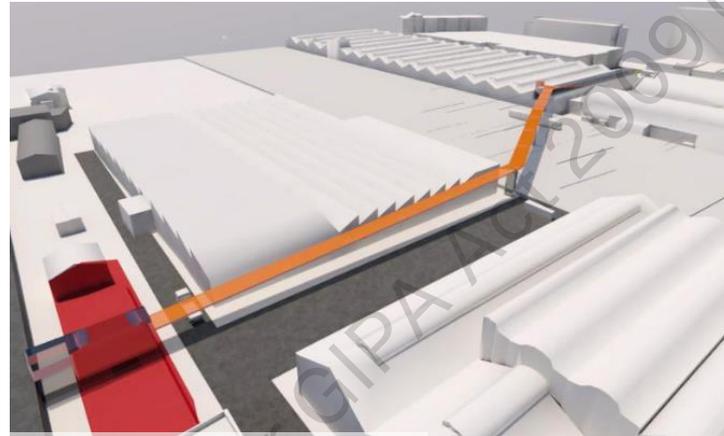
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Previous studies

2008 and 2017 Studies for the Carriageworks to Australian Technology Park Pedestrian Link

Arup were previously commissioned to review the site constraints including constructability and develop sketches of bridge concepts for preliminary costing. We note that the previous design brief included the requirement to provide DDA ramps (grade 1 in 20) which resulted in substantially longer ramps.

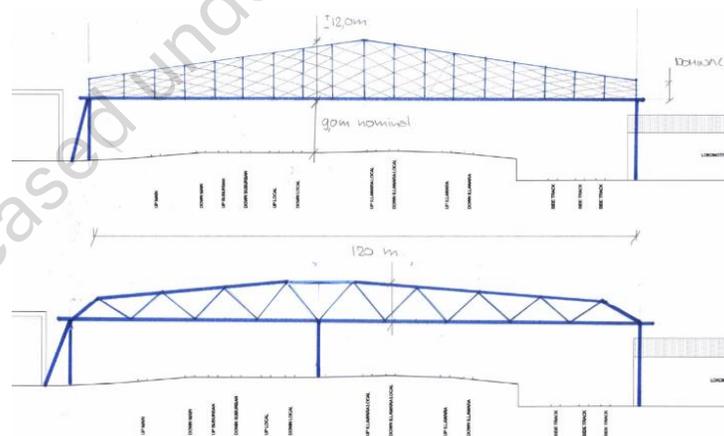
Sites to the east were favoured over the western alignments because the bridge length could be minimized. In addition the siting provided space for a pier at approximately midspan considering the constraints in the rail corridor. As the 2008 study was undertaken prior to the installation of the new Redfern Station crossing, 'duplication' of an existing alignment was not the cause to discount these options. The second platform access bridge at Redfern Station is currently under construction and due for completion in Q1 2023.



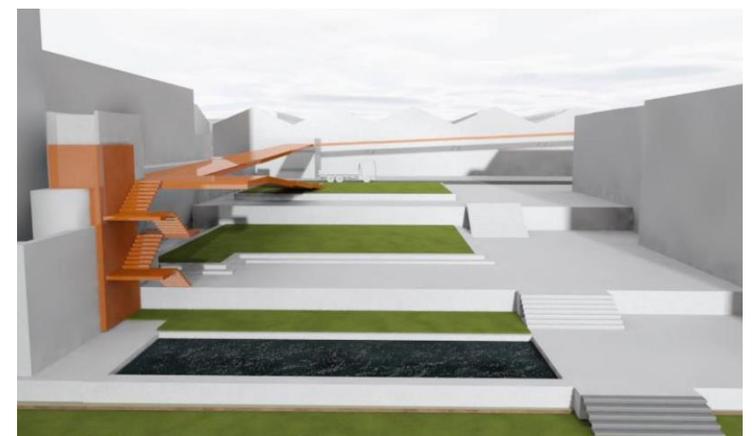
North landing to Wilson Street



South landing option in Locomotive Shed bay



Truss options with pier, clear spans are ~50-120m



South landing option along village square (between Channel 7 and CBA)

Future demand and travel time savings

Summarised from SCT Consulting, 2021, Bridge Catchment Analysis

Current demand

340-420 journeys per weekday,
53% are less than 1000m in length



Main beneficiaries of the additional bridge are cross-rail corridor journeys to/from:

- Urban residential
- Public services (University of Sydney)
- Commercial (North and South Eveleigh precincts).
- Light industrial and commercial (Waterloo and Green Square)

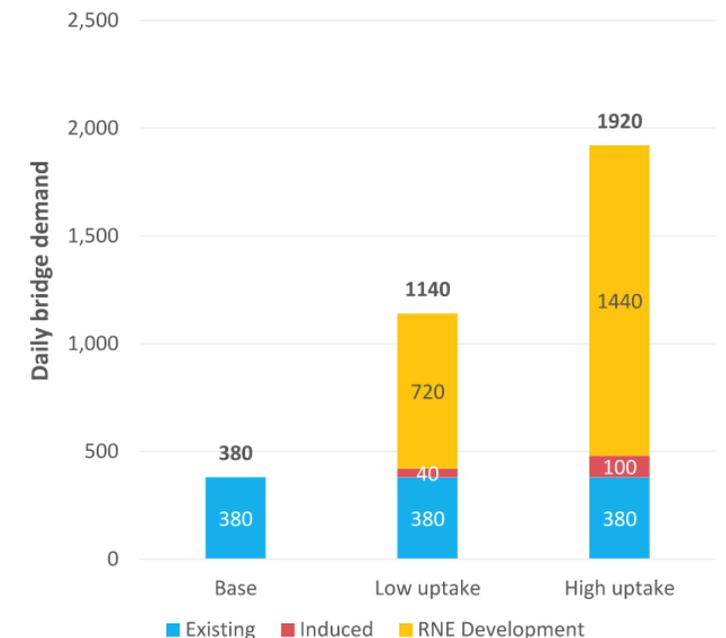
Travel time savings

3-6 minutes per trip

- The average travel time saving is 5-8 minutes (SCT Consulting, 2021).
- This needs to be further reduced to 3-6 minutes to account for time going up and down from the bridge.
- Savings become less pronounced for origins and destinations further away from the bridge.

Future demand

1140 – 1920 crossings per day



For comparison, George Street, between Albert Street and Phillip Street, Redfern has ~2000 journeys per day on both weekdays and weekends (City of Sydney Open Data Pedestrian Surveys, March 2022)

Travel time savings

Example Travel Route from ABS to Waterloo Station

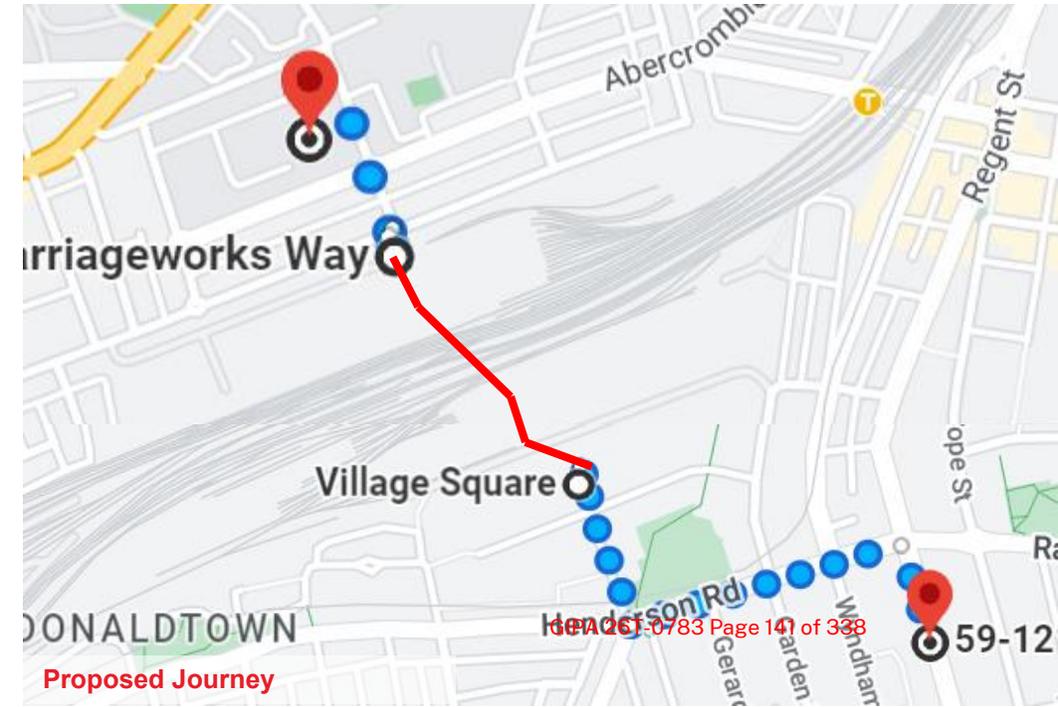
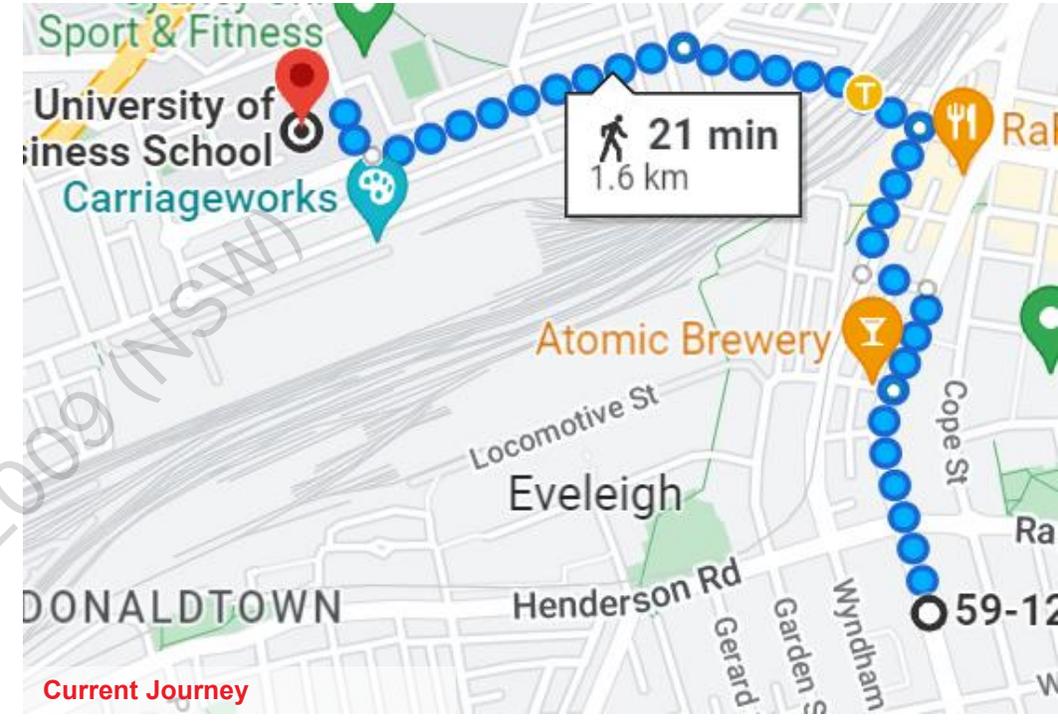
From University of Sydney Abercrombie Business School (ABS)
To Waterloo Metro Station

Current journey time: 21 min

Proposed journey time: 17 min

- ABS to Carriageworks 3 min
- Carriageworks to Village Green via bridge 3 min
- Stairs/Lifts at each end 2 min
- Village Green to Waterloo Station 9 min

Approximate time saving: 4 min



If we did build a bridge, what might it look like?

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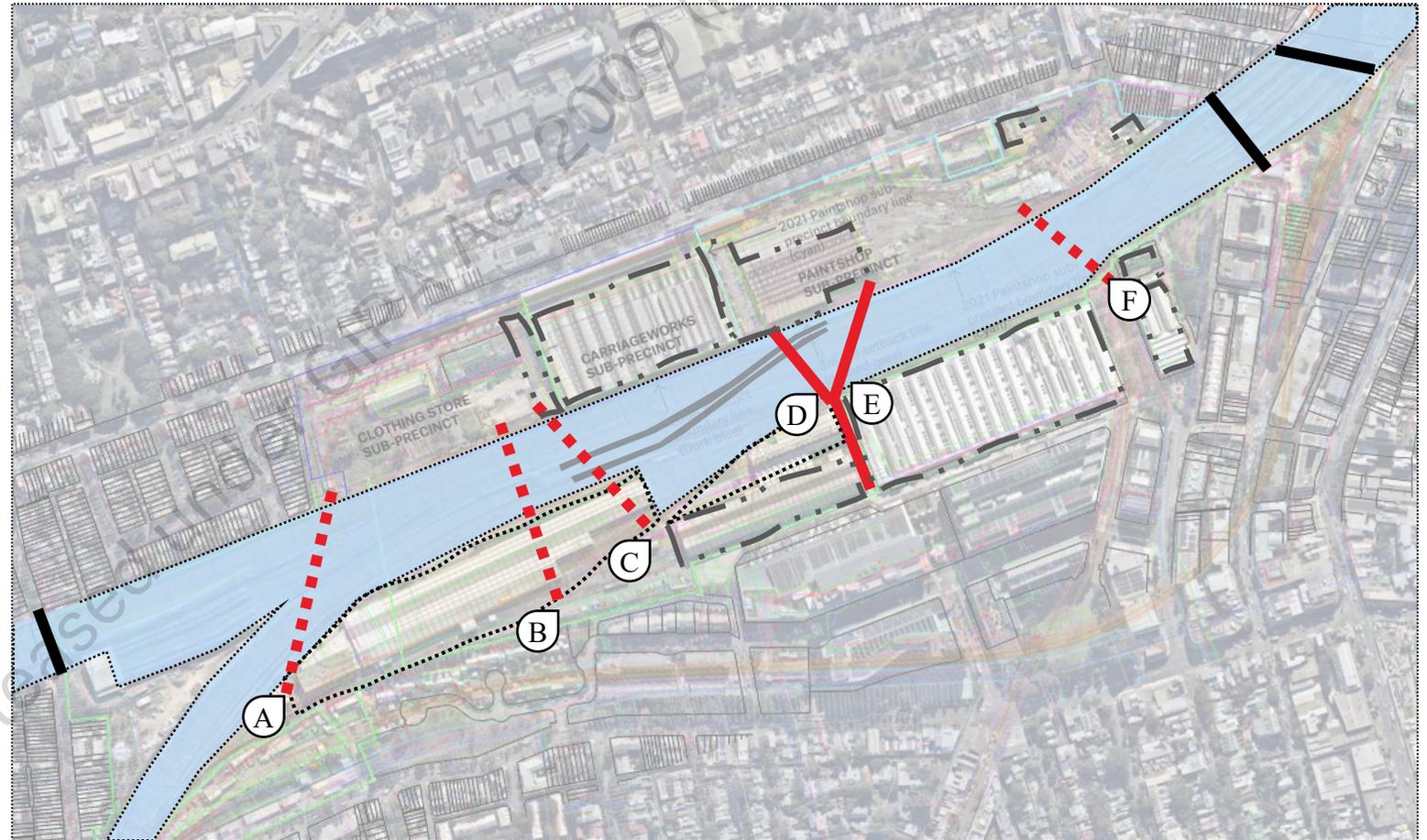
Bridge alignment options – Where should it go?

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- Study alignment
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- Existing connection
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- ~ ~ ~ ~ ~ Illawarra Dive (tunnel)
- - - - - Eveleigh Maintenance Centre
- . - . - Heritage

The rail corridor poses significant physical and operational constraints.

Approvals from Sydney Trains will be a pre-requisite for any design or construction activity.



Bridge siting map

Structural Form – What form should the bridge take?

The truss has been selected as an appropriate form for the feasibility study.

- Access should be through the structure to reduce the elevation required to clear rail assets.
- The structure cannot be ‘raised’ from the rail corridor but must be craned, launched or pivoted.
- At this stage, focus has been placed on testing a feasible solution and the truss has been selected for that purpose.
- Aesthetics and form will be an important consideration for heritage and Connection to Country.

Example structural typologies

Height of spanning structure

Truss



5 – 6.5m

Tied arch



10 – 15m
(from tie to highest point of the arch)

Cable-stayed

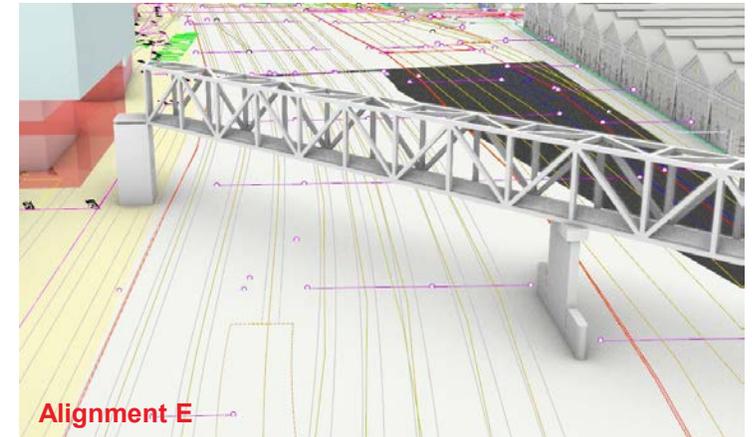
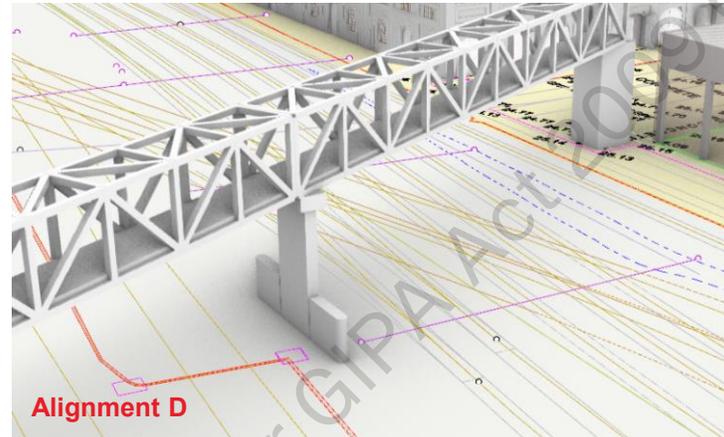


Pylon height ~25 – 30m

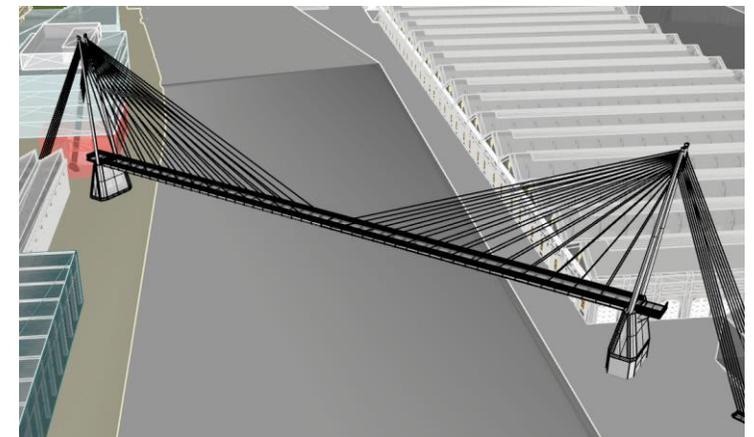
Bridge support in the rail corridor

A pier in the rail corridor is required and needs Sydney Trains approval.

- A pier is required, otherwise the structure becomes very large
- Sydney Trains approval is required to build a pier in the rail corridor
- This section of the rail corridor is a key artery close to Central Station
- Design and construction requirements for the Sydney Trains corridor are very stringent
- Approvals and possession pose a program and cost risk



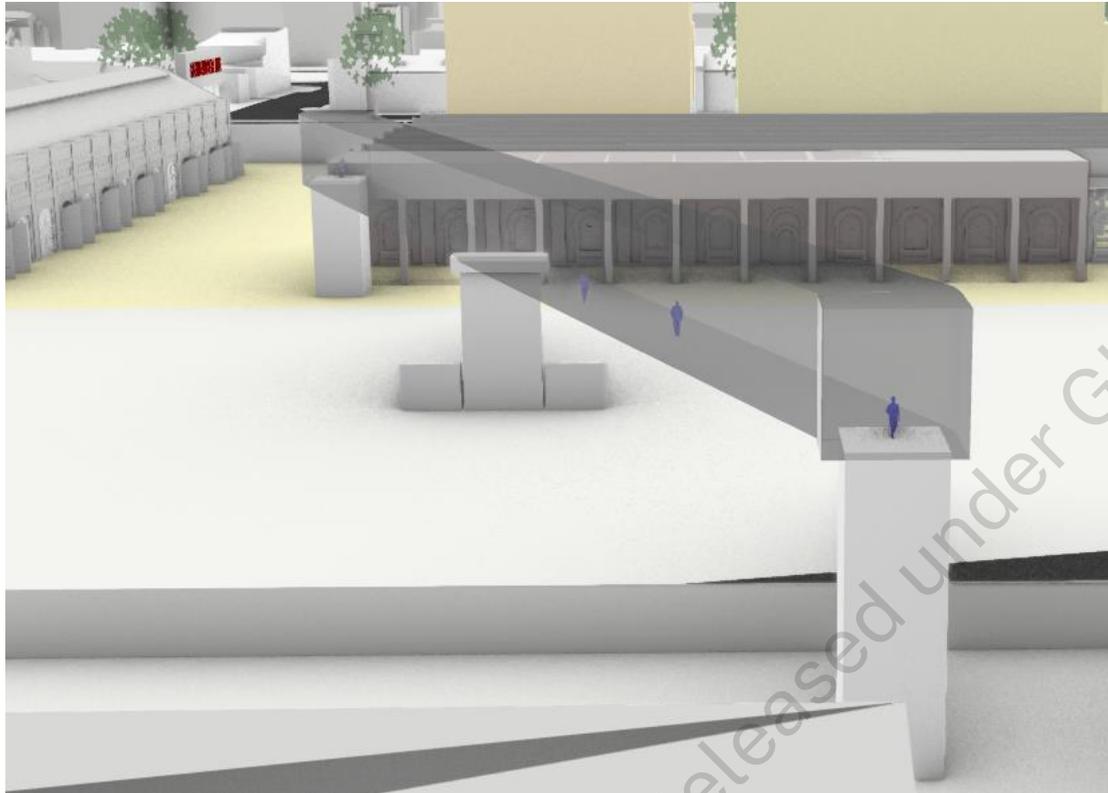
Piles, pile cap, deflection walls and pier



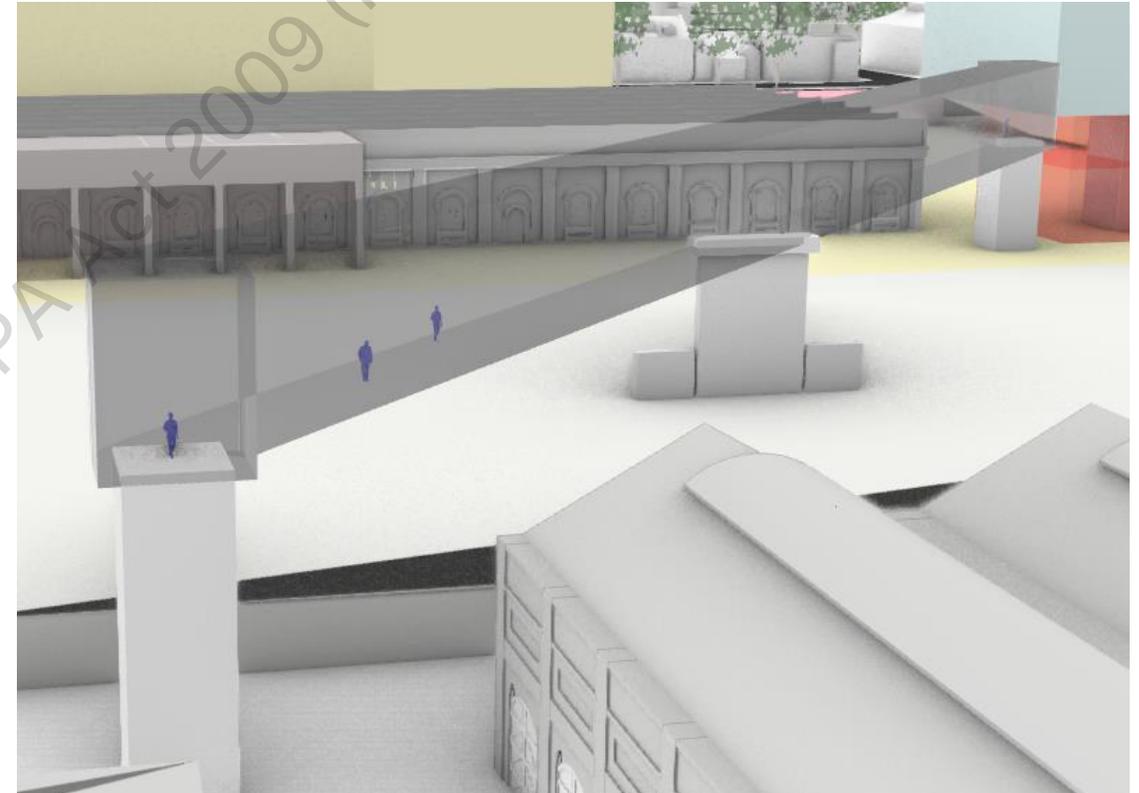
Cable supported bridge clashes with buildings

Bridge size

The bridge will have substantial structural volume.



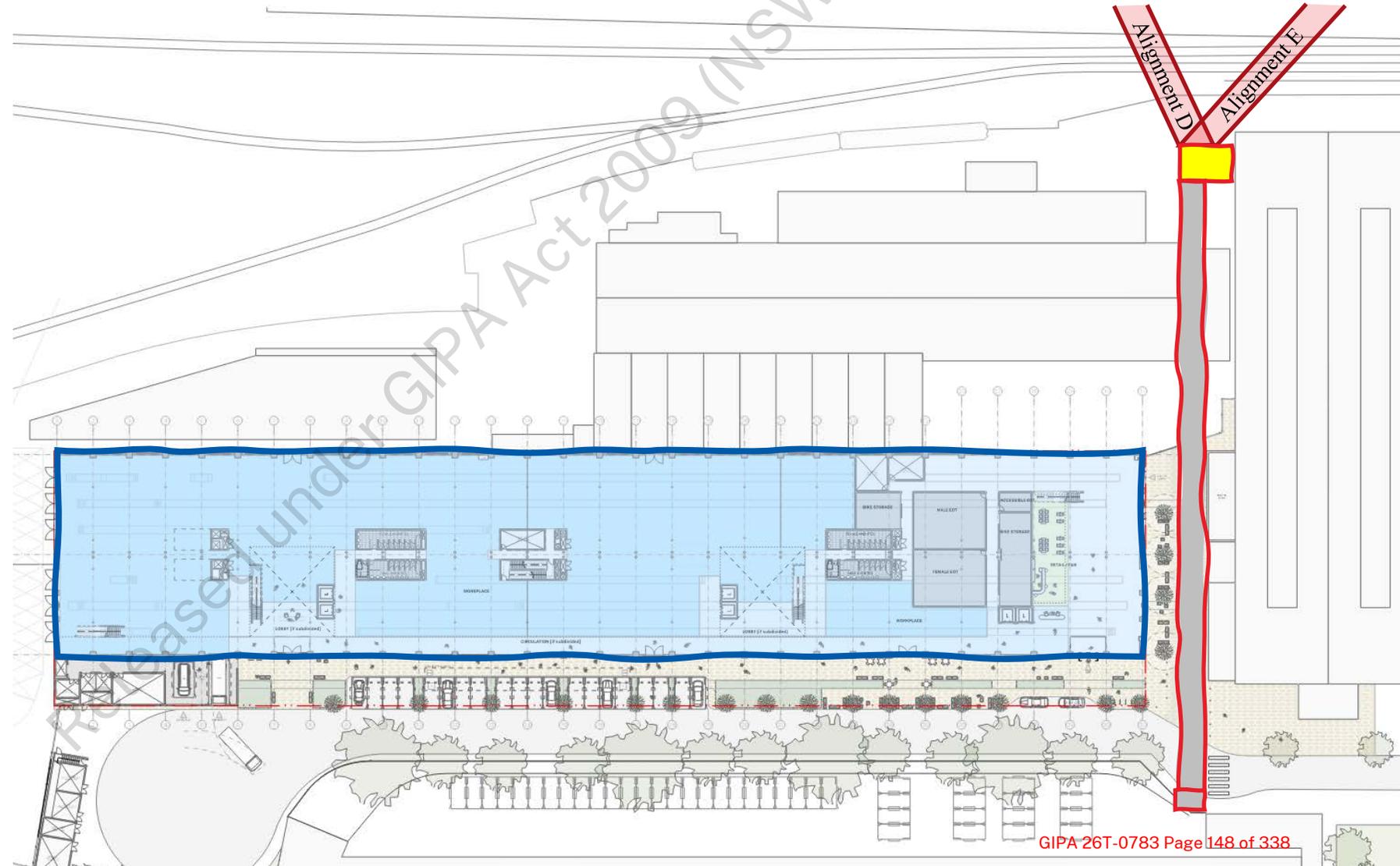
Alignment D: 5m (W) x 5.5m (H)



Alignment E: 5m (W) x 7m (H)

Bridge location in relation to LES building

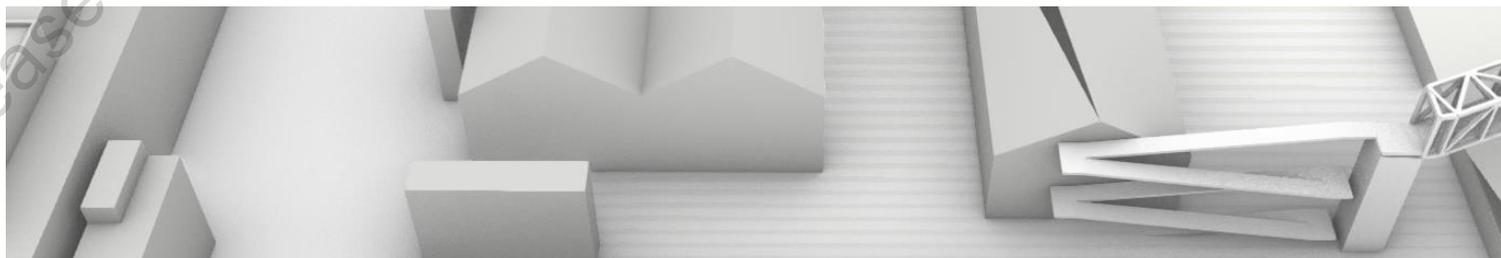
-  Bridge Alignments
-  Abutment
-  Lift/Stairs/Deck
-  LES building



Southern ramps

A ramp is not appropriate for the south landing due to the space needed.

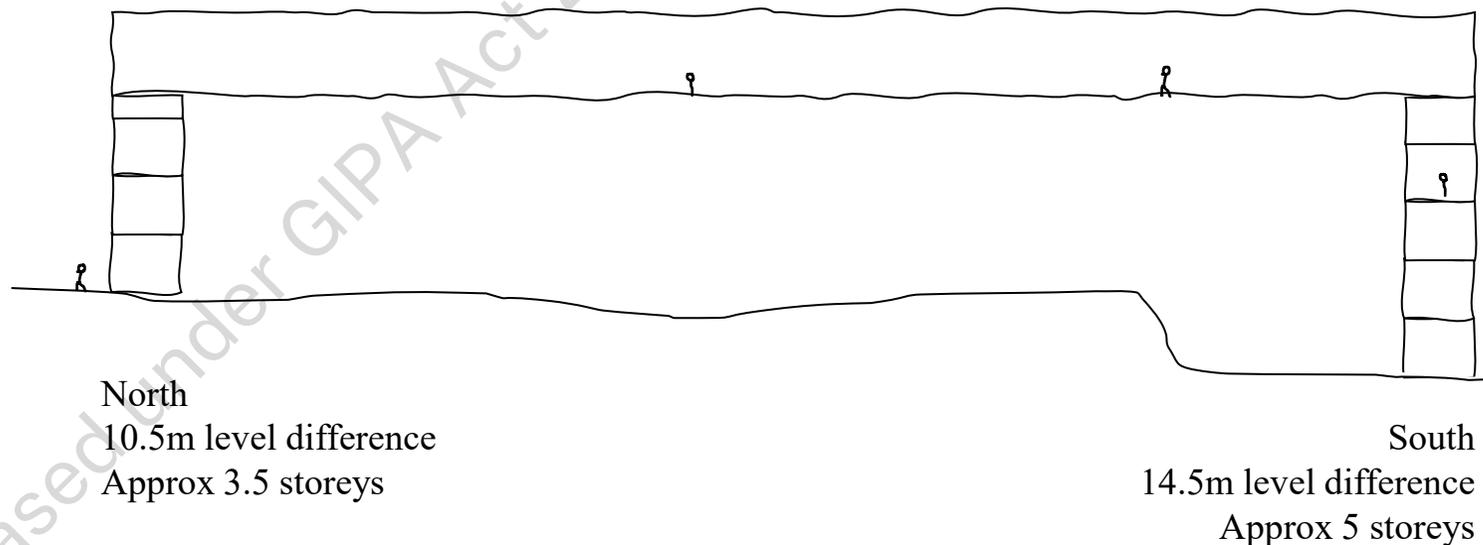
- The substantial changes in level mean a long run is needed.
- E.g. the steepest grade permissible (Grade 1 in 8 cyclist ramp) without rest zones results in a run to the base of the Channel 7 building.
- DDA compliant ramps (grade 1 in 20) would be longer still.
- A long ramp increases the walking time for pedestrians and the number of switchbacks for cyclists to navigate.
- Similar typologies would be applied if ramps were used on the north.



Minimum two lifts at each end

A minimum of two lifts are needed at each end as the stairs are not a convenient means of accessing the bridge.

- The bridge must comply with DDA requirements.
- Stairs alone are not accessible or comfortable for many customers, especially at this elevation.
- E.g. for train stations, 5m is generally where designs start shifting from stairs to escalators.
- Minimum two lifts are required at each end for maintenance and redundancy.
- A staircase is still required in case of breakdowns.



Local comparisons

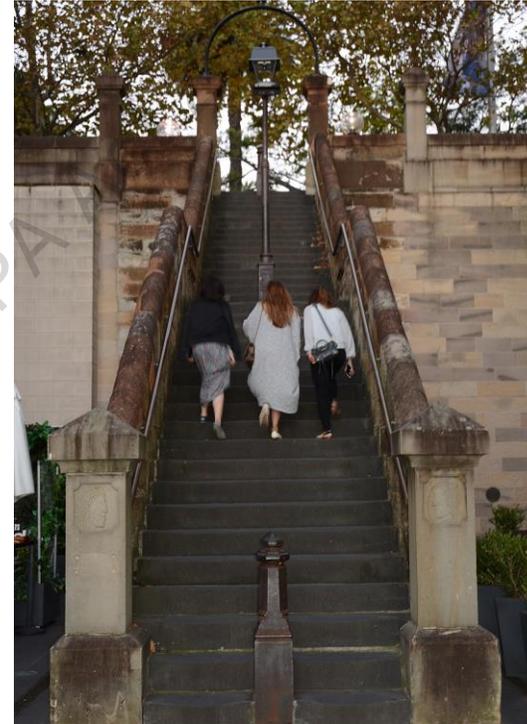
A minimum of two lifts are needed at each end as the stairs are not a convenient means of accessing the bridge.



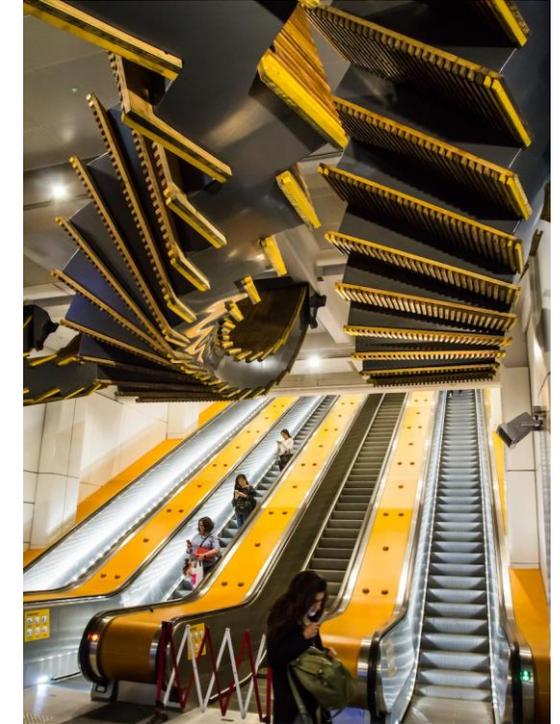
Butler Stairs, from Domain to Woolloomooloo, ~19m



Argyle Stairs, from Argyle Street to Cahill Expressway, ~10m



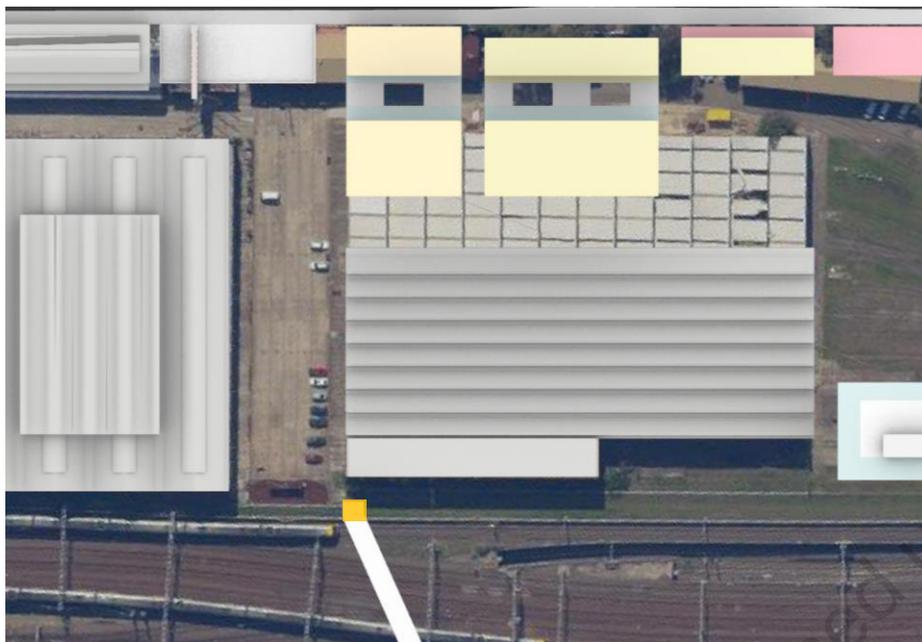
Moore Steps, from East Circular Quay to Macquarie Street, ~8m



Wynyard Station Escalators, ~13m

Bridge - Northern Abutment

The north landing is slightly less complex than the south, and stairs and lifts will generally fit in the space available.



Alignment D – behind the Paintshop annex



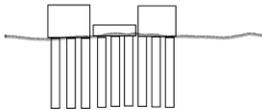
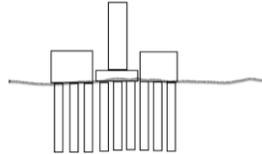
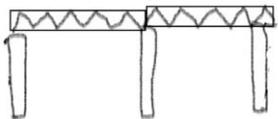
Alignment E – towards the Fan of Tracks

- A ramp has not been considered as there is no ramp in the south, and similar spatial constraints apply.
- The landing choice can influence how people are directed into the development and local area.

Bridge - Construction

Constructing the bridge will be difficult, expensive, and take several years.

- Construction must occur during a rail shut down (i.e., possession).
- Limited number of possessions; best case 2 x 48 hours per year.
- Very optimistic duration of 3.5 years.
- Realistic duration of 4-5 years, excluding design and approvals (additional 1-2 years).
- Future adjacent developments and interfaces not considered.
- All works require Sydney Trains approval.

Example construction sequence (very optimistic)	Minimum possessions	Minimum years
Piles in rail corridor 	2	1
Pile cap install and cast, and set formwork deflection wall 	1	0.5
Install pier, deflection wall, concrete pour and strip 	1	0.5
Bridge: - Lift and bolt north span - Lift and bolt south span 	2	1
Fitout and miscellaneous	1	0.5
Total:	7 possessions <i>minimum</i>	3.5 years <i>minimum</i>

Conclusion

The Redfern North Eveleigh Bridge will be a very challenging and expensive bridge to build and does not provide outstanding time savings or convenience for users.

Next steps:

Internal TfNSW benefits and value assessment.

Business case preparation and funding submission (subject to passing value and benefits assessment).

If the bridge is built:

There will be a high cost and long program due to physical and operational constraints.

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Conclusion

A detailed benefits assessment and business case is required.

	Connect the North and South Eveleigh communities			Accessible	
	Provide local permeability across the rail corridor			Sustainable	
	Safe			Sympathetic to the industrial heritage of the area	
	Comfortable			Connection to Country	
	Convenient			Value for Money	
	Provide time savings for pedestrians and cyclists				

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Redfern North Eveleigh Paint Shop Precinct

Bridge catchment analysis

Released under GIPA Act 2009 (NSW)

19 April 2023 | Version 3.0

Quality Assurance

Project details

Project number:	SCT_00248		
Document name:	RNE Paint Shop Precinct Working Paper 4 – Bridge Catchment Analysis		
Client:	Transport for NSW	ABN:	18 804 239 602
Prepared by:	SCT Consulting Pty. Ltd.	ABN:	53 612 624 058

Information	Name	Position	Signature
Author:	s74 Out of scope	Principal Consultant	s74 Out of scope
Reviewer:		Director	
Authoriser:		Director	

Version	Date	Details
1.0	11 October 2021	Issued to TfNSW
2.0	18 April 2023	Updated to reflect bridge design
3.0	19 April 2023	Refinement of land-use areas to rezoning approval

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Questions to be answered

Is there a need and/or benefit of an active transport bridge between North and South Eveleigh?

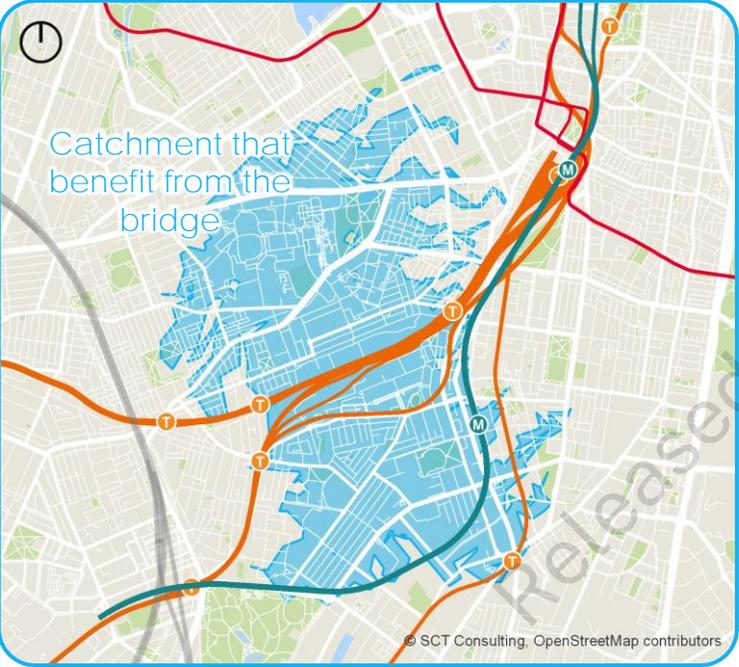
1. Who would benefit from the bridge?
 - Spatial catchment analysis
2. What quantum of people are likely to use the bridge?
 - Review of existing travel patterns (analysis of mobile phone data)
 - Confidence in data
 - Expected users of the bridge
3. How integral is the Redfern-North Eveleigh development to improving use of the bridge?
 - Potential increase in users of the bridge based on changes in land-use

Executive summary



Catchment analysis

Determine who benefits from the bridge compared to the existing scenario and future scenario (with Redfern Station southern concourse).



Travel time saving

An estimate of the average travel time benefits for a customer using the bridge (compared to other alternative corridor crossings).

Average travel time saving

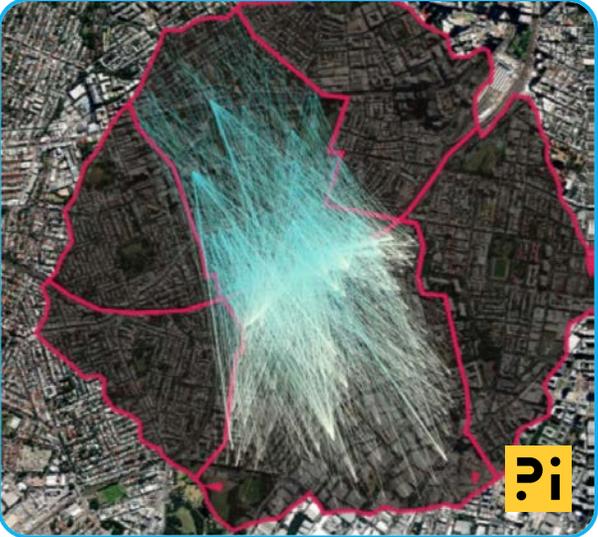
3 minutes

per cross-corridor journey.

Executive summary

Current demand

Who may use the bridge based on existing travel patterns?

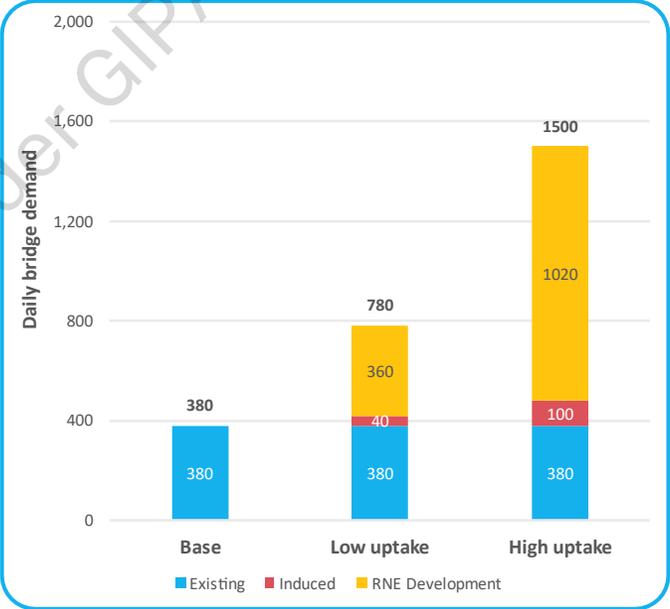


340-420 journeys per weekday

Future demand

Increase in customers due to:

- Provision of the bridge (induced trips)
- Development of Redfern North Eveleigh Precinct



Productivity

The cumulative benefit of the bridge.

19-75 people-hours saved

per typical weekday.

[01]



Who would benefit from the
bridge?

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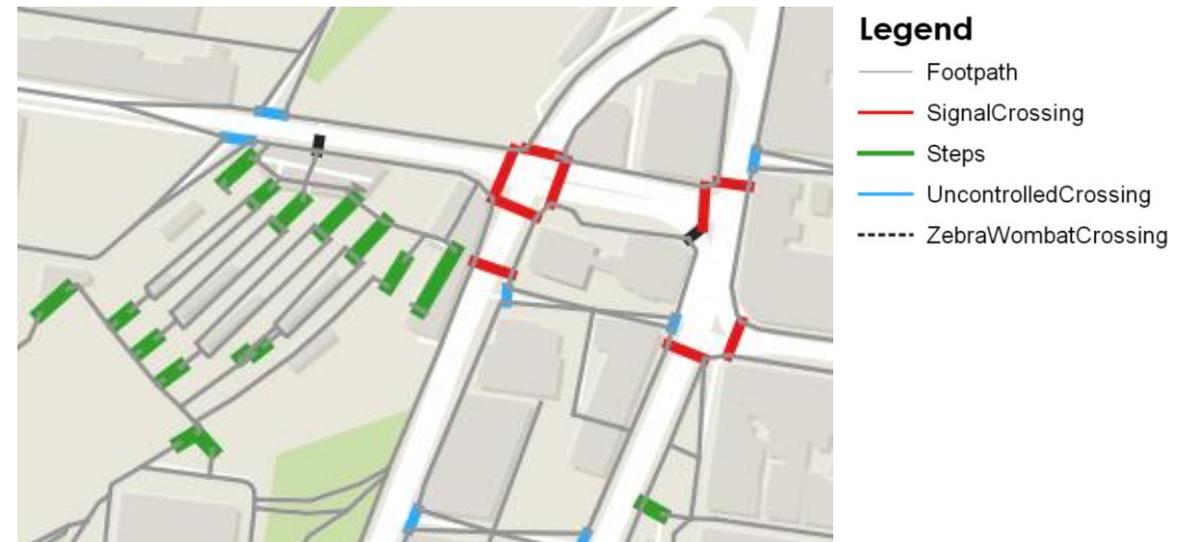
Existing rail corridor crossings



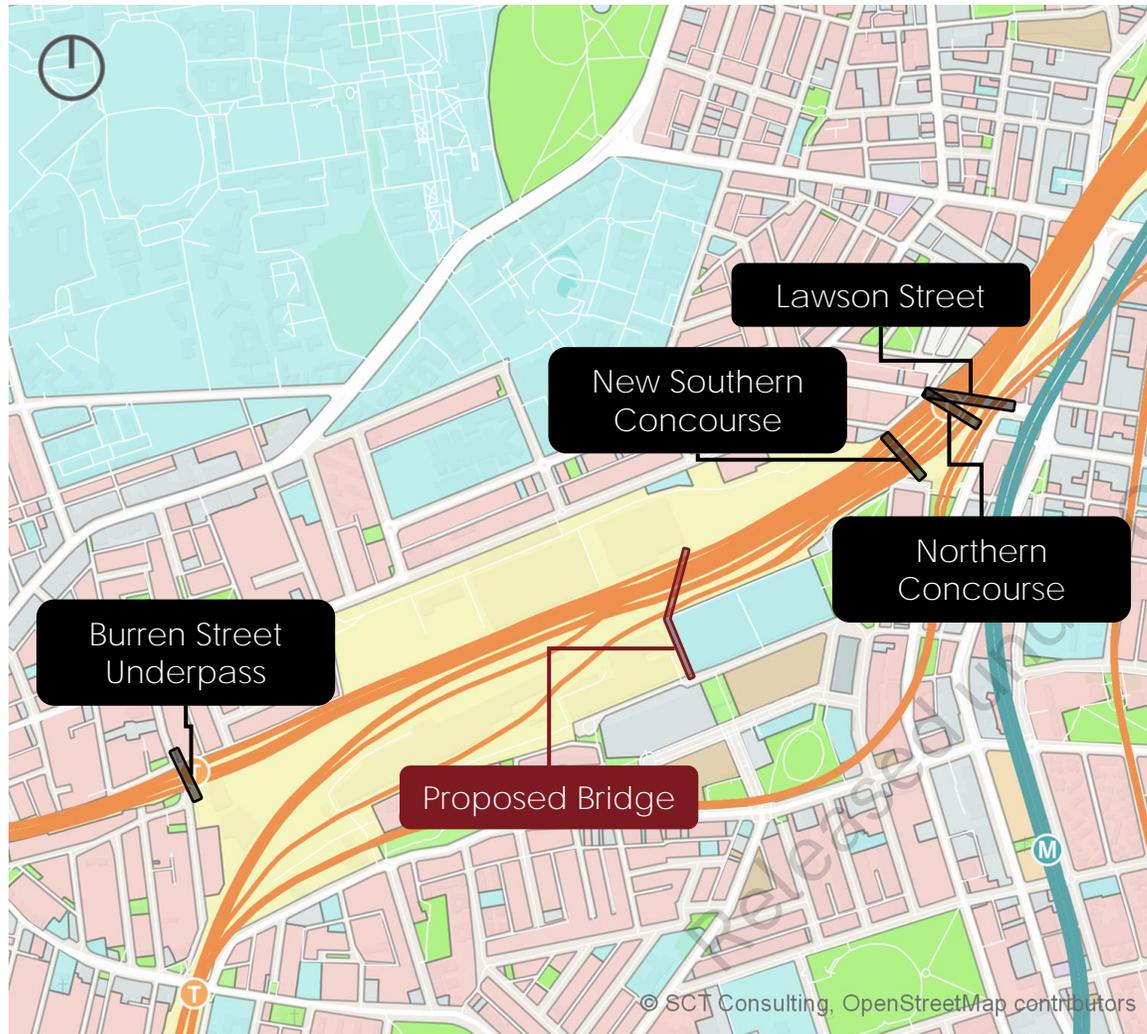
All existing crossings included in analysis.

- Travel time for each route is calculated based on a typical walk speed of 1.35 metres per second
- Additional travel time has been added for:
 - Vertical transport (including stairs or lifts)
 - Road crossings (penalty by type: signalised, zebra and uncontrolled).

Example Extract:
Redfern Station concourses (existing northern and new southern).

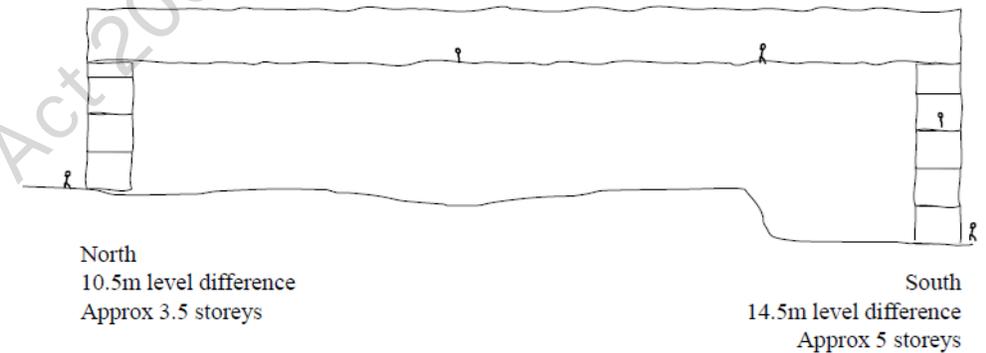


Proposed rail corridor crossing



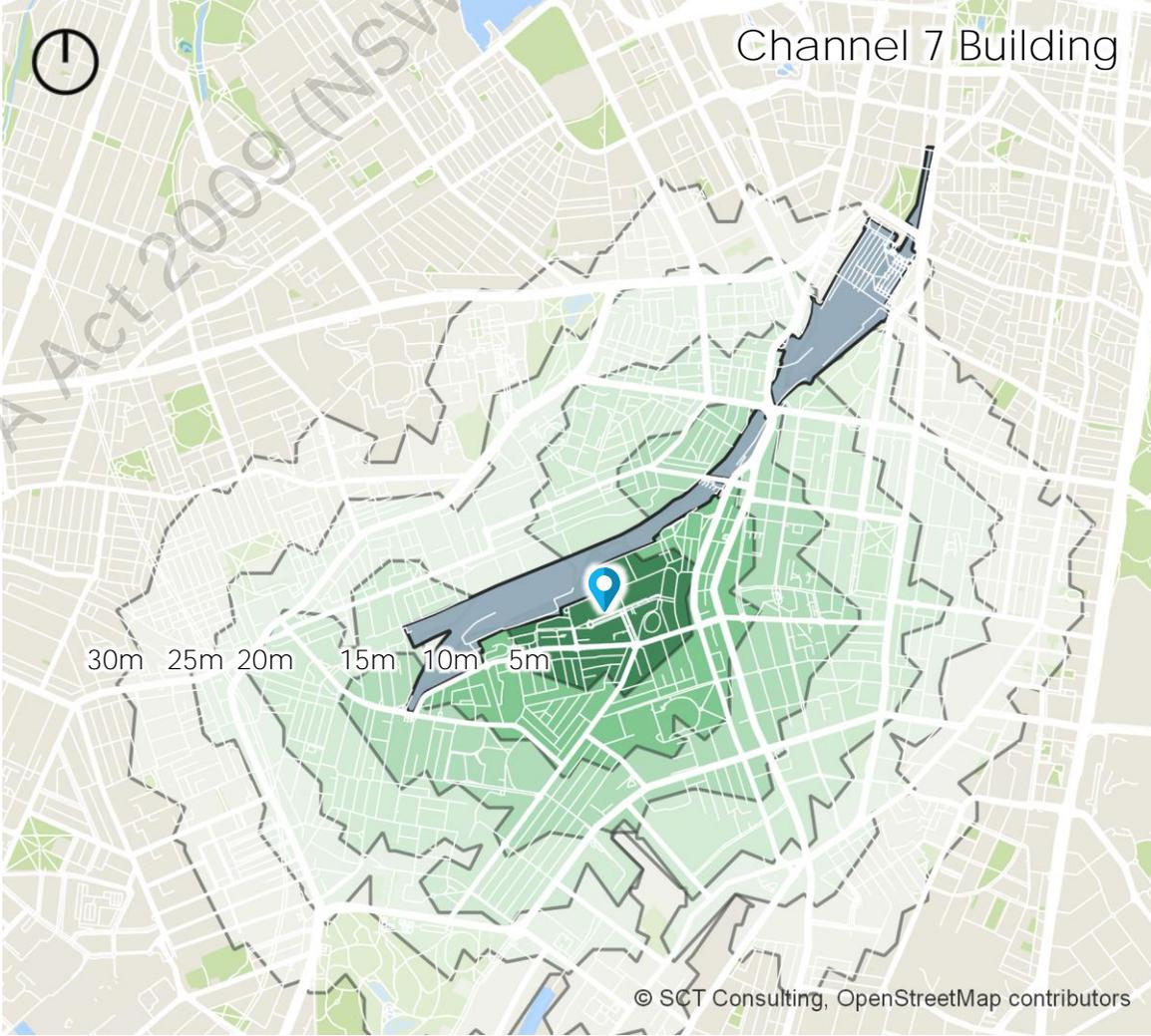
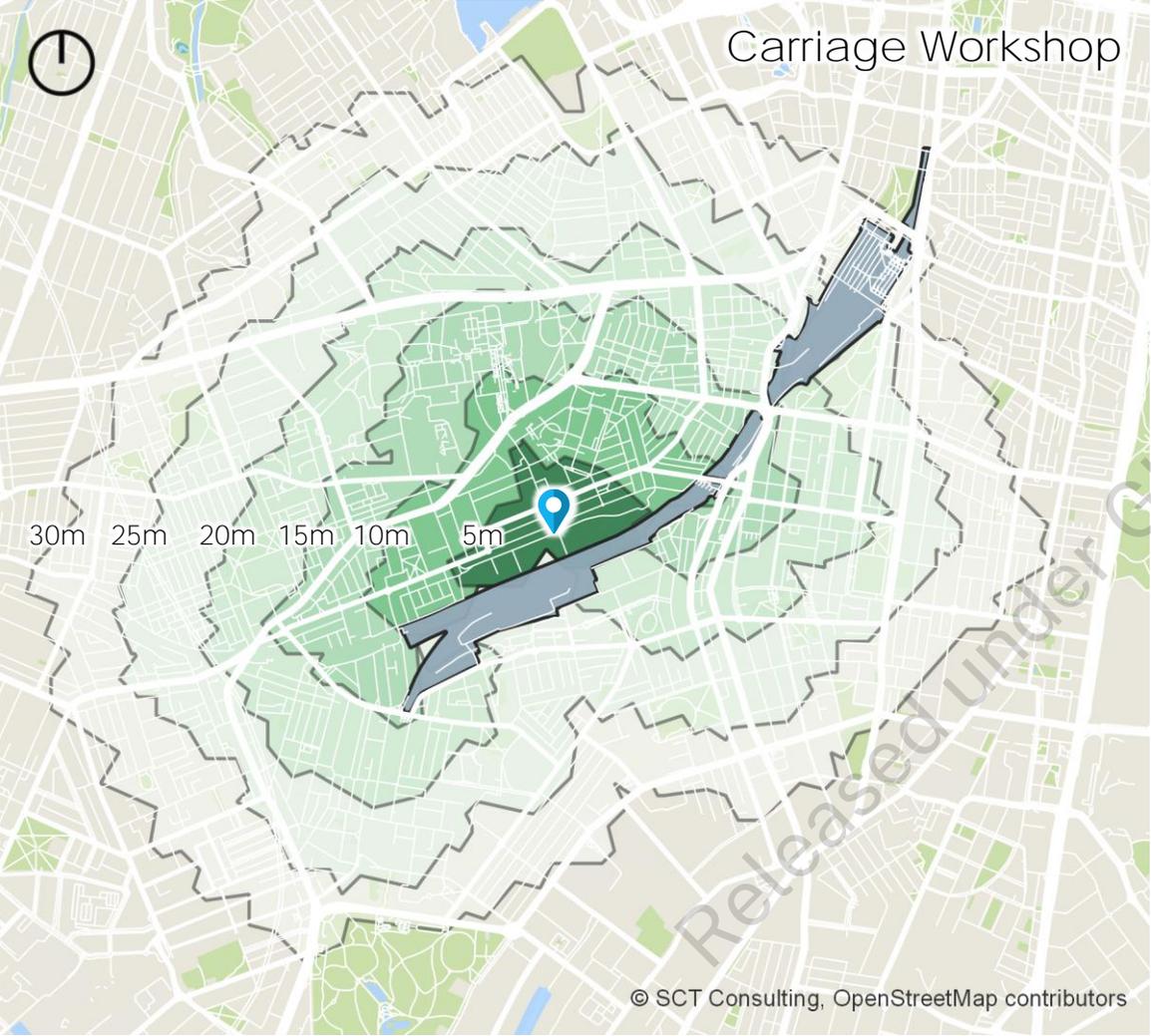
Proposed bridge included in assessment. Based on Arup (November 2022) design pack, the following characteristics have been included:

- Bridge connecting North and South Eveleigh
- Lift access is provided on both ends, based on indicative heights:



- Due to the height of the bridge, it is unlikely users would utilise the stairs as the main form of vertical transport (unless they opt to do so from a hedonic perspective i.e. for exercise).
- Therefore the travel time of the bridge has been based on a first-principles lift travel time assessment.
- With two lifts at each end, the average trip time (including wait and travel time) is estimated at 33 seconds (north) and 39 seconds (south).
- Including the lifts and extended deck (over the maintenance facility) on the southern end to Locomotive Street, the total crossing time is approximately 4 minutes.

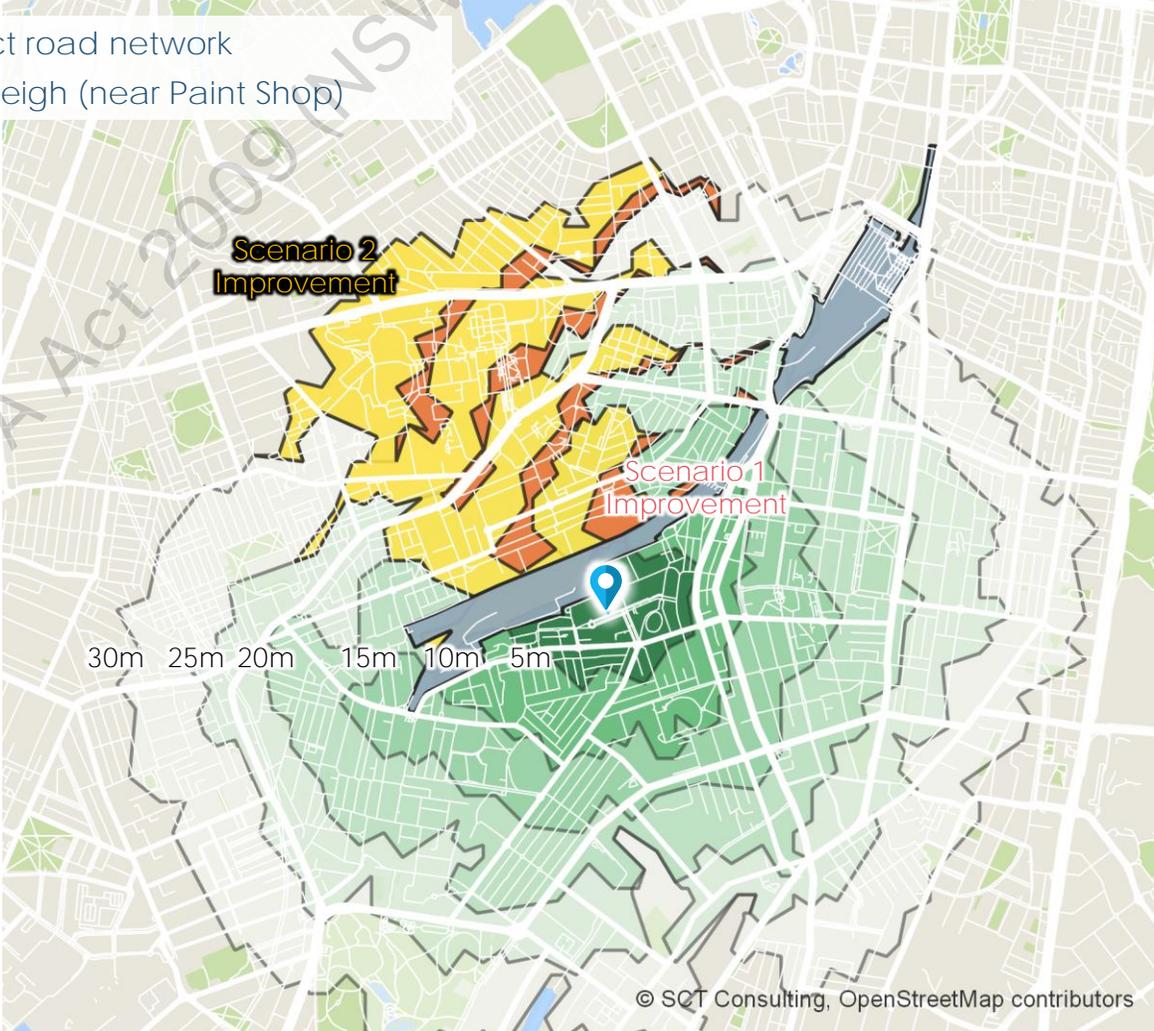
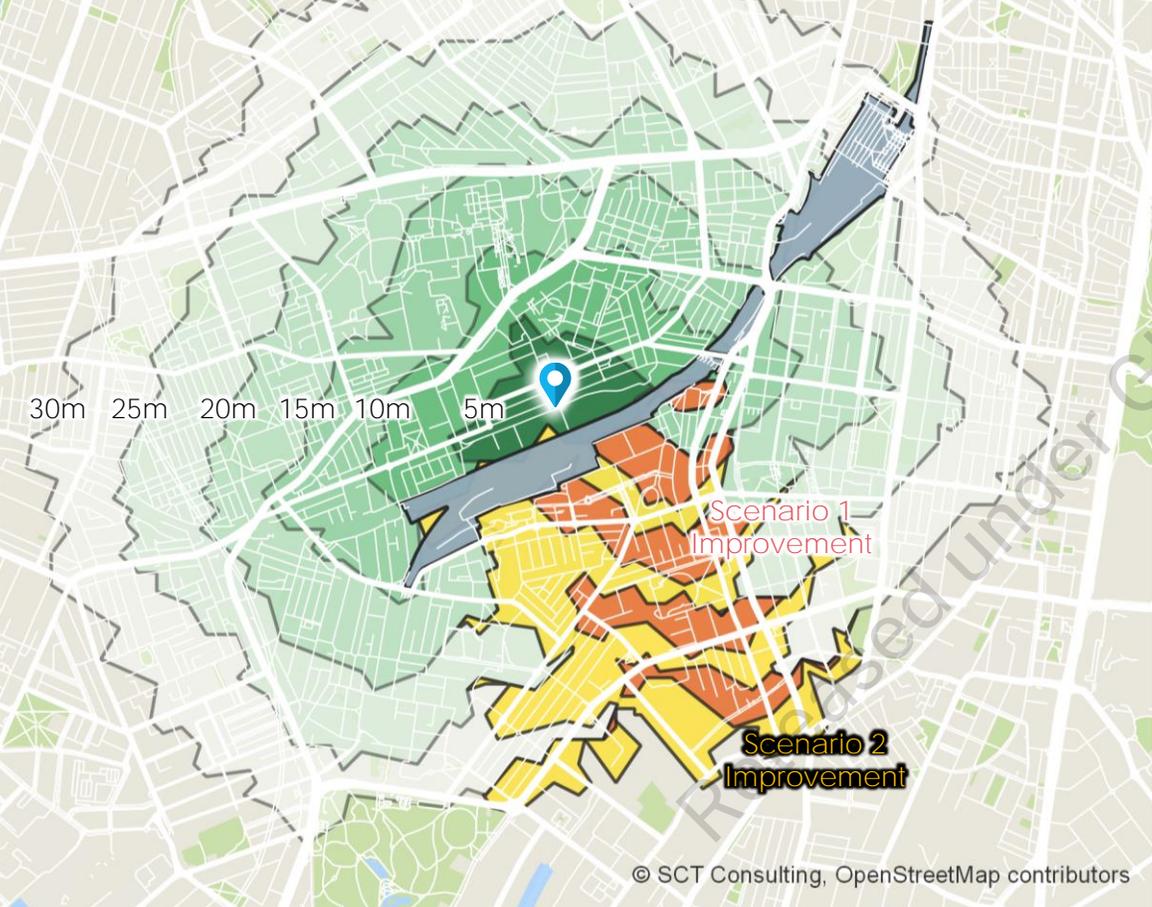
Existing 30-minute walking catchments



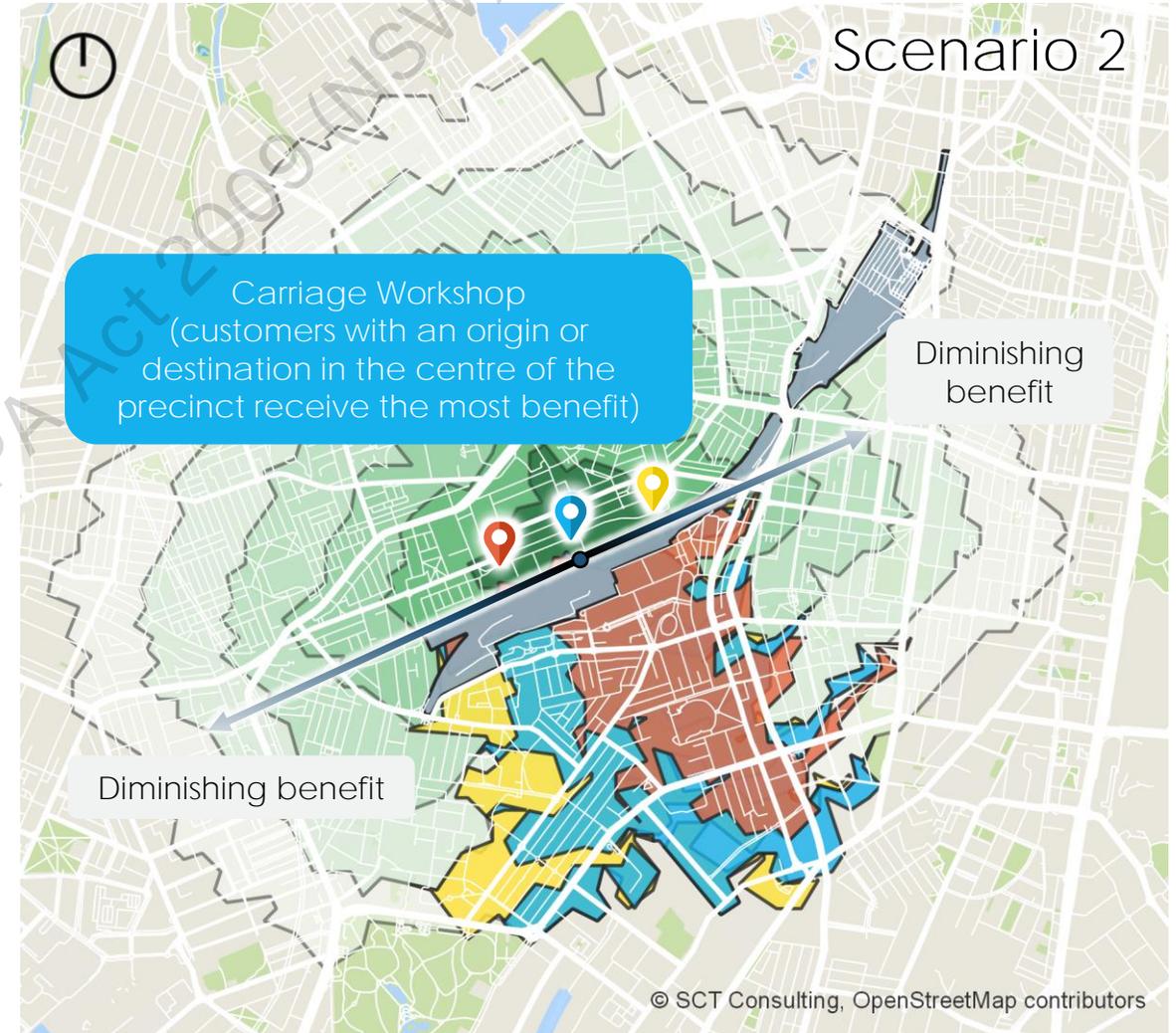
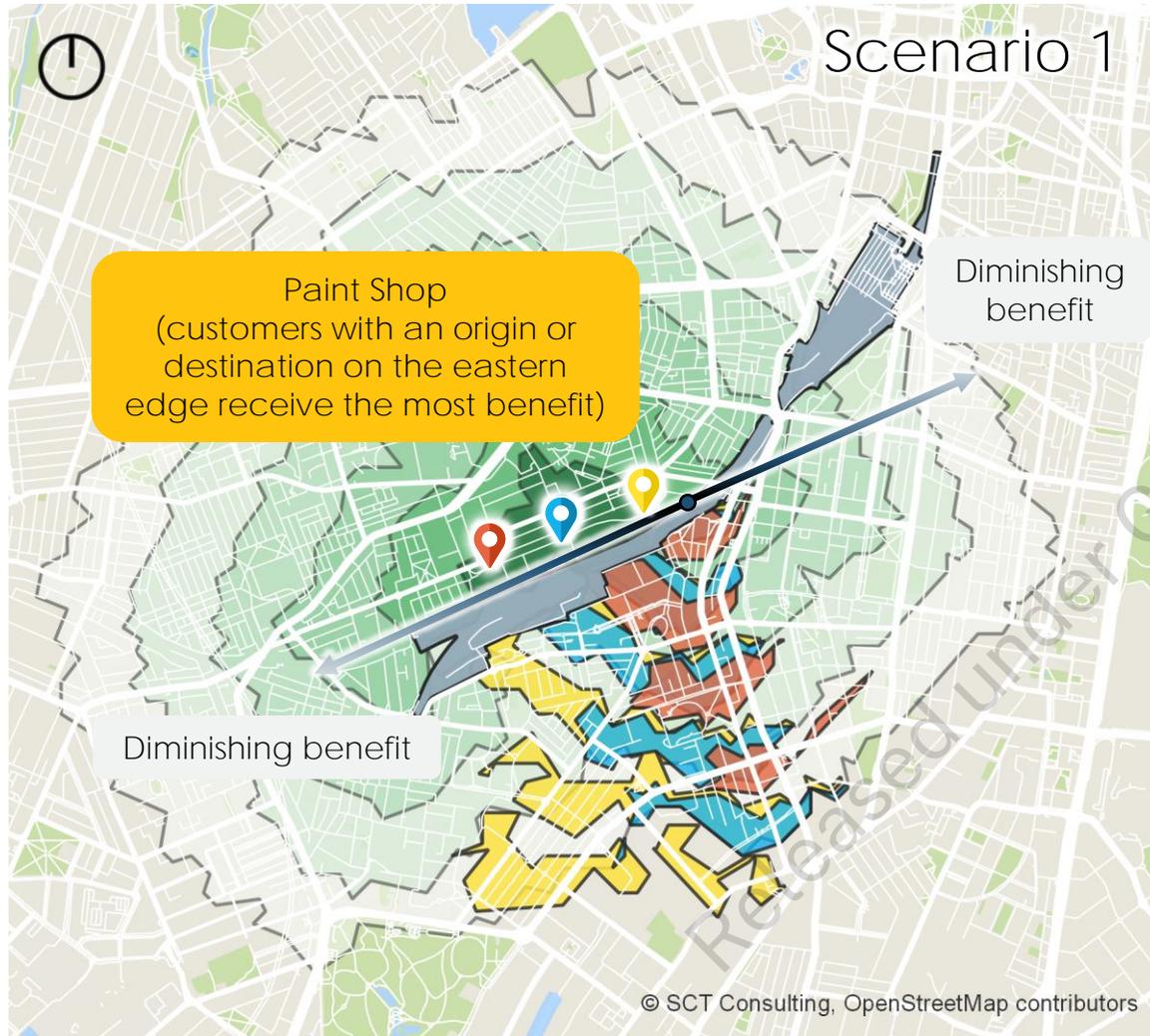
Improvements to 30-minute walking catchments

Scenario 1 – Redfern Station Southern Concourse with Paint Shop sub-precinct road network

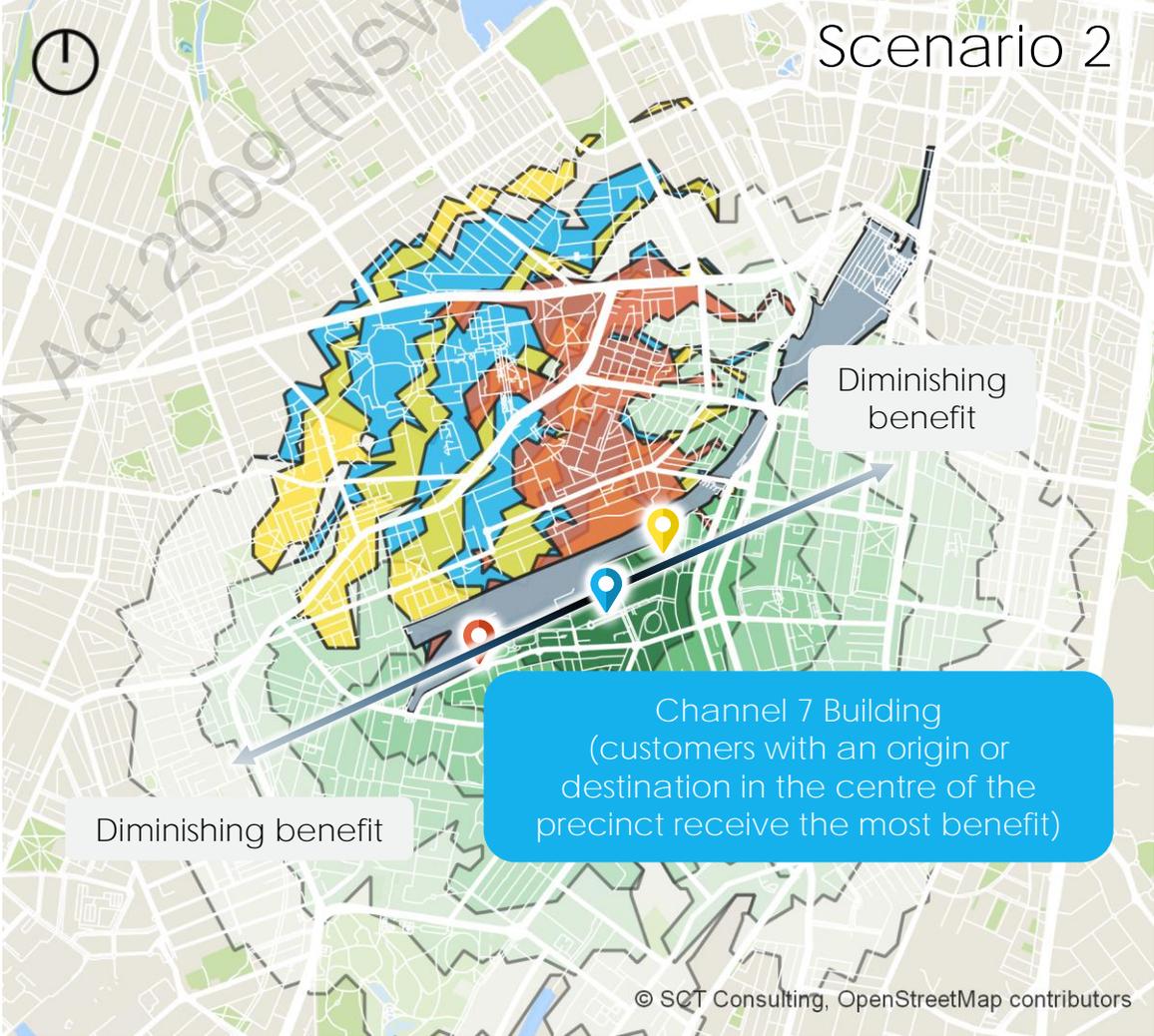
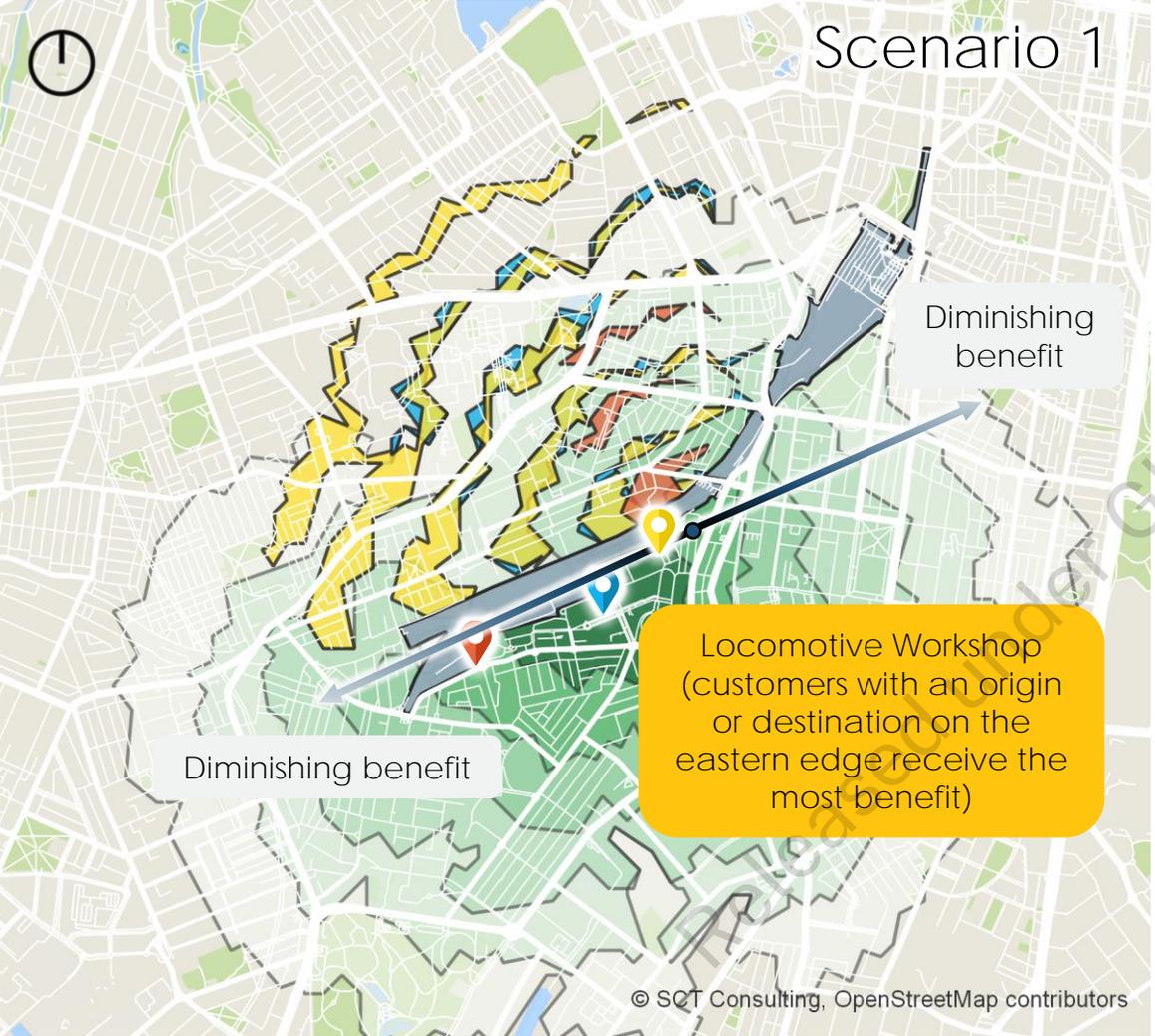
Scenario 2 – Scenario 1 with additional bridge between North and South Eveleigh (near Paint Shop)



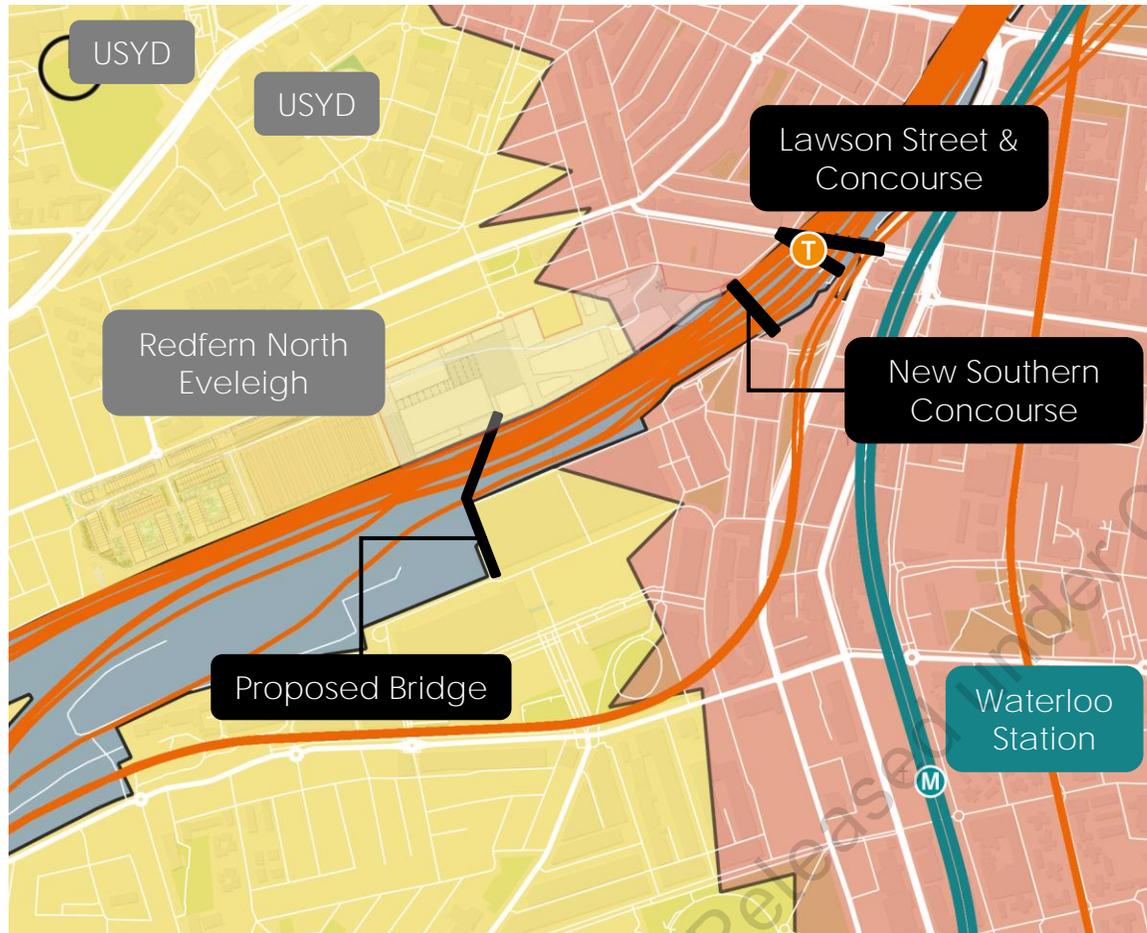
Northern Sites – Improvements by location



Southern Sites – Improvements by location



Southern Concourse versus Proposed bridge



Scenario 1 – Redfern Station Existing and Southern Concourse

Scenario 2 – Proposed bridge between North and South Eveleigh

A comparison of the two alternative groups of crossing options, resulted in the following observations of cross-corridor journeys:

- Bridge connecting North and South Eveleigh is the most attractive (from a travel time perspective) for majority of the RNE precinct.
- The New Southern Concourse is more attractive for access to the commercial developments on the eastern end of RNE.
- Customers (in particular students) who may travel between Waterloo Station (Sydney Metro City & Southwest) and the University of Sydney (USYD) Campus may find it more attractive to use the new proposed bridge between the station and campus.
- Other key destinations such as Broadway Shopping Centre, University of Technology Sydney (UTS) are better served by the New Southern Concourse and existing connections to the north.

Scenario 2 benefit – land use

Main beneficiaries of the additional bridge are cross-rail corridor journeys to/from:

- Urban residential
- Public services (University of Sydney)
- Commercial (North and South Eveleigh precincts). Noting RNE precinct is currently listed as infrastructure (railways).
- Light industrial and commercial (Waterloo and Green Square)

Travel time saving (range)

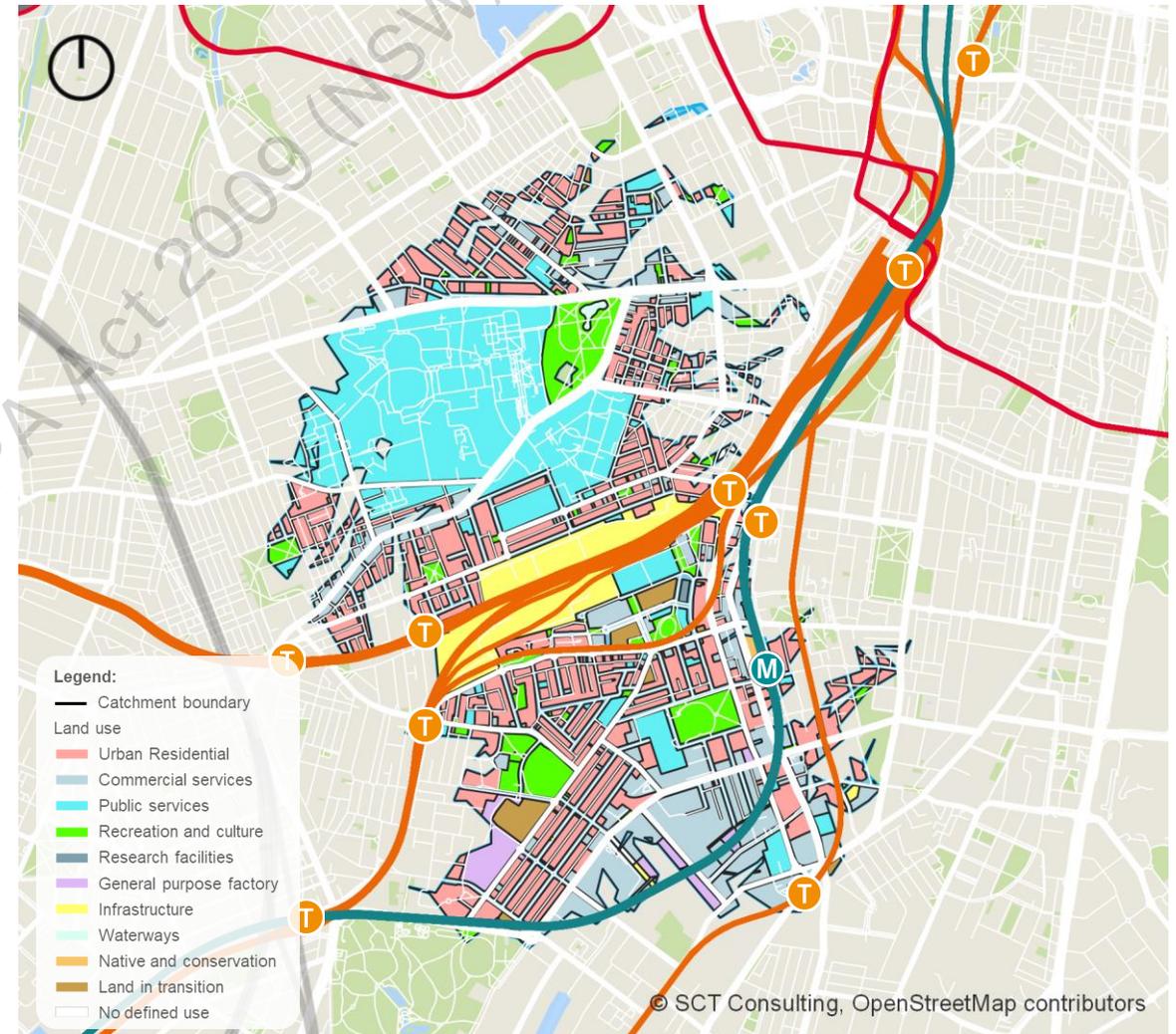
Up to 12 minutes

For cross-corridor journeys in the highlighted regions. For some customers, the benefit may be more; likewise, the benefit may be less for others.

Average of travel-time saving

4 minutes

Weighted average based on forecast population and employment data (2036) across the walking catchment.



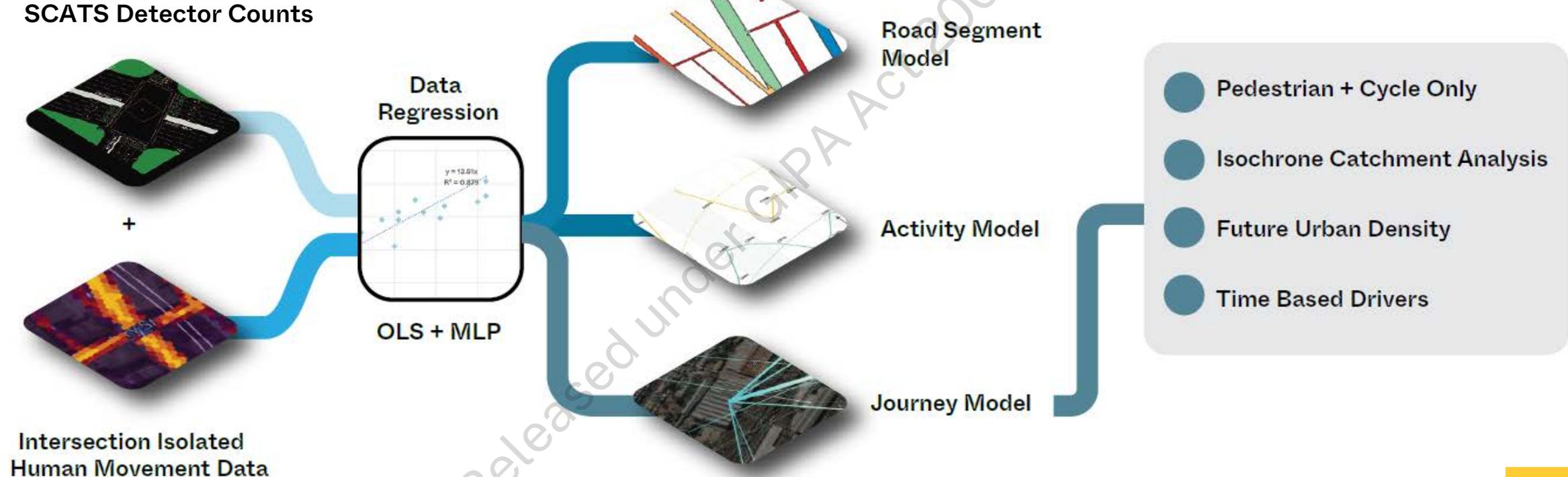
[02]

What quantum of people are likely to use the bridge?

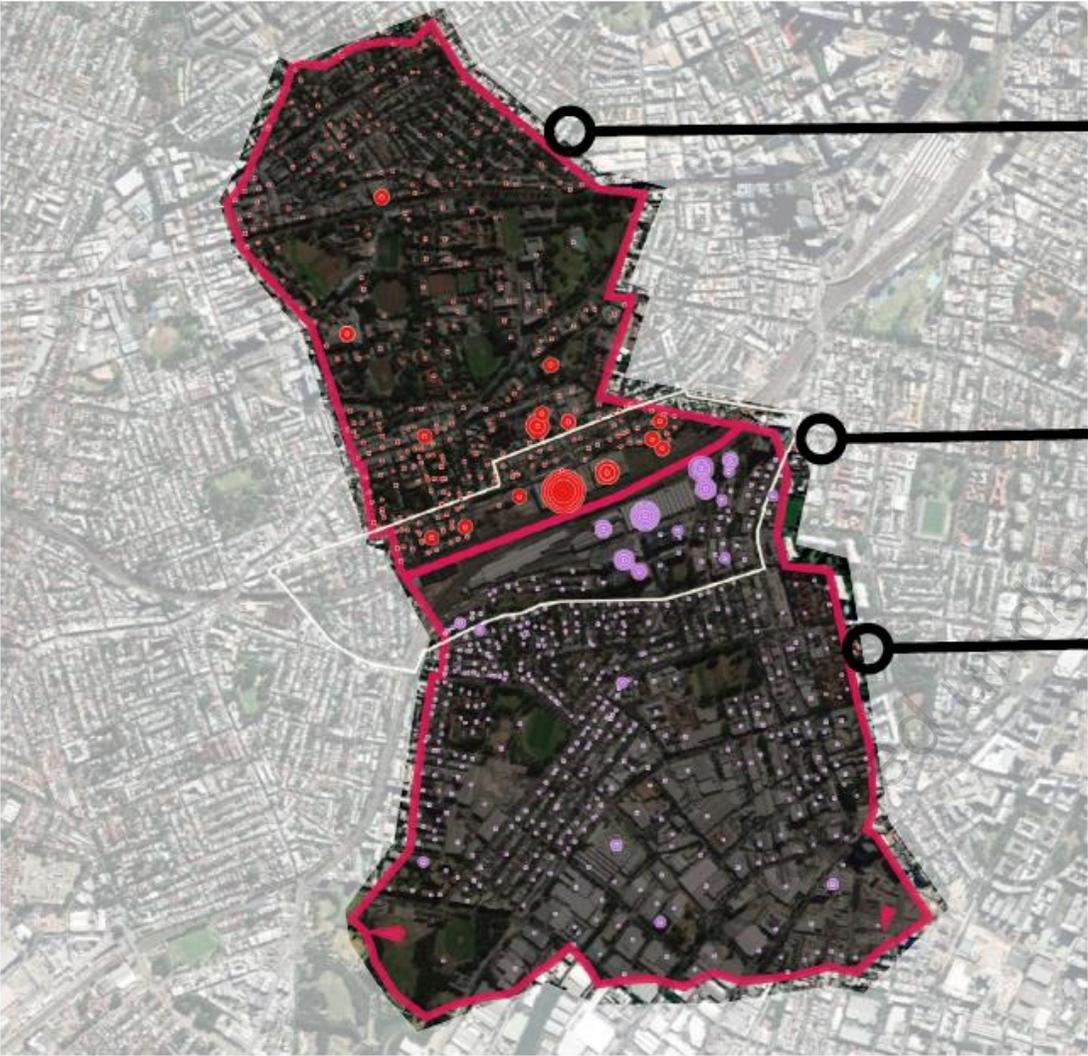
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Bridge demand analysis - process

We used a number of data processing methods to predict the number of journeys per hour that would use the proposed bridge.



Current observed cross-corridor origins and destinations



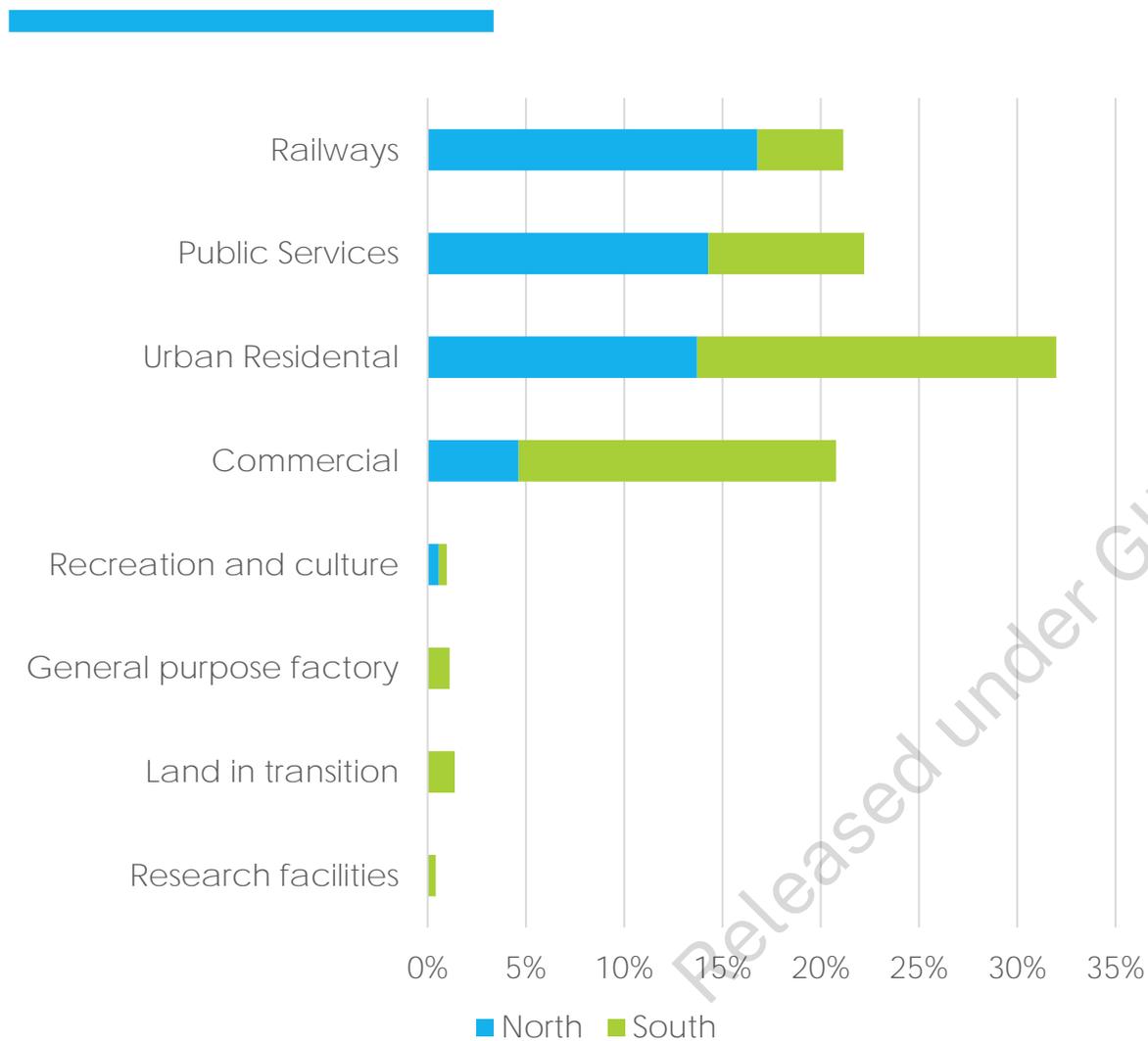
North
Primary Generator: **University of Sydney**

Precinct Boundary
Percent of Total Journeys: **26%**
(Excludes Redfern Station activity)

South
Primary Generator: **Urban Residential**



Cross-corridor trips by land-use



(Excludes Redfern Station activity – some areas around corridor including RNE precinct are classified as Railways)

Journey origins

(the reciprocal can be assumed for a return journey)

32%

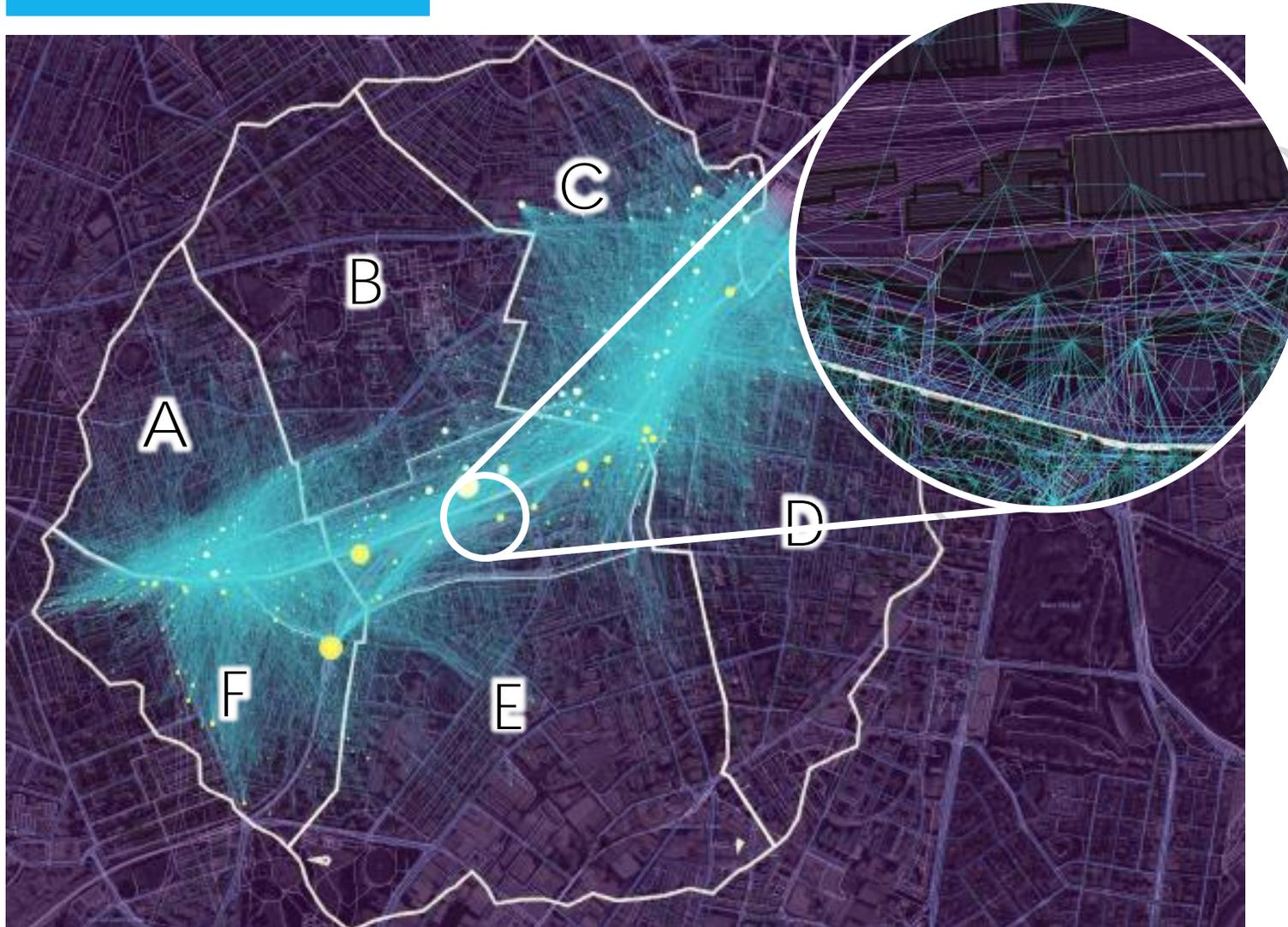
Journeys originate from residential land-uses

< 2%

Journeys originate from land-uses classified as recreation and culture.



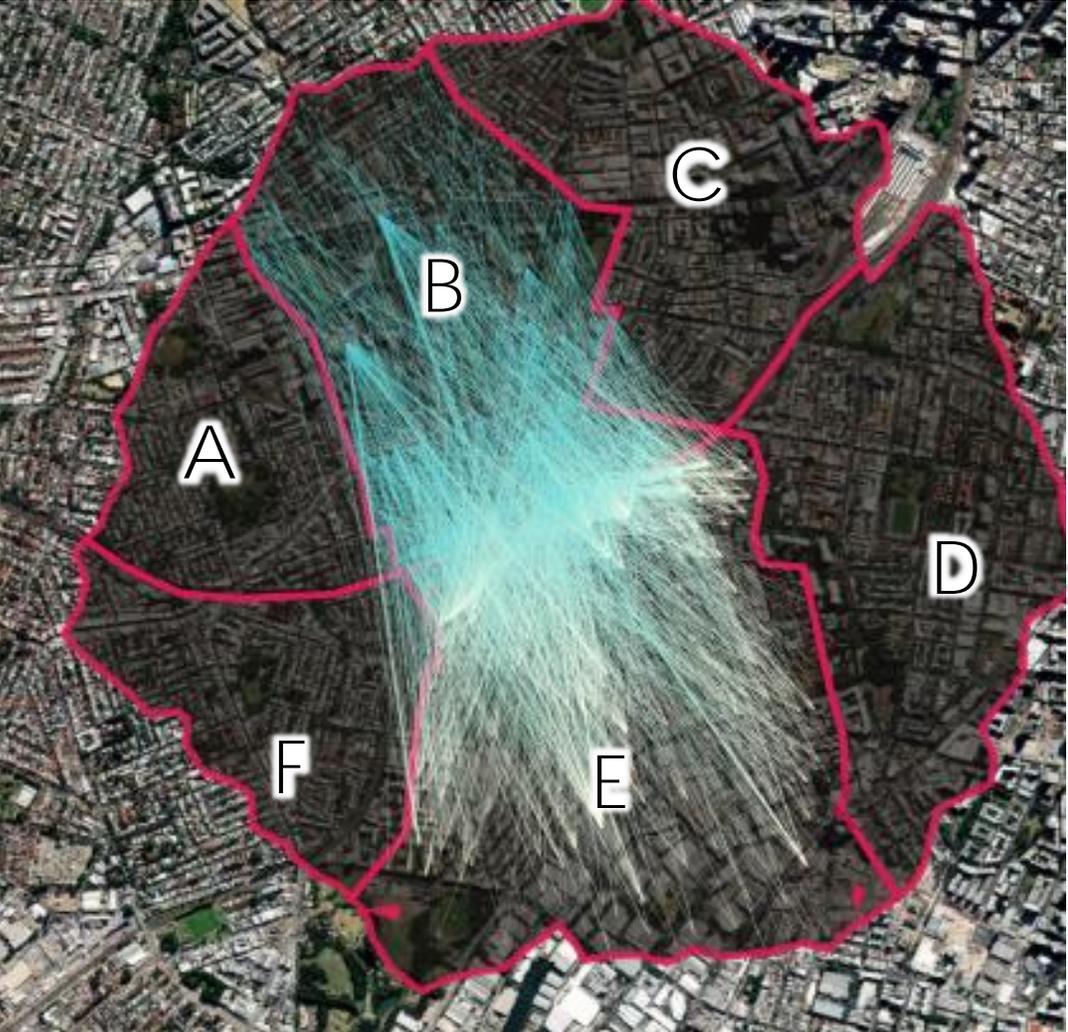
Study area - benefiting regions (and O-D connections)



Catchment analysis indicates greatest benefit to Regions B and E (and travel to and from these locations).

Regions A – F and C –D already have high levels of permeability, which is corroborated by high observed trips.

Current demand for bridge



Validated trips

340-420 journeys per day

R² Average

0.8875

Typical walking characteristics

53% less than 1000m in length

Peaks:

8:15-9:15 AM

4:45-5:45 PM



About the model:
Model Size: 152,470 Journeys
Number of Buildings: 1,391
Time Interval: 15 minutes
Time Series: Weekdays Only
Mode: Non-Vehicle

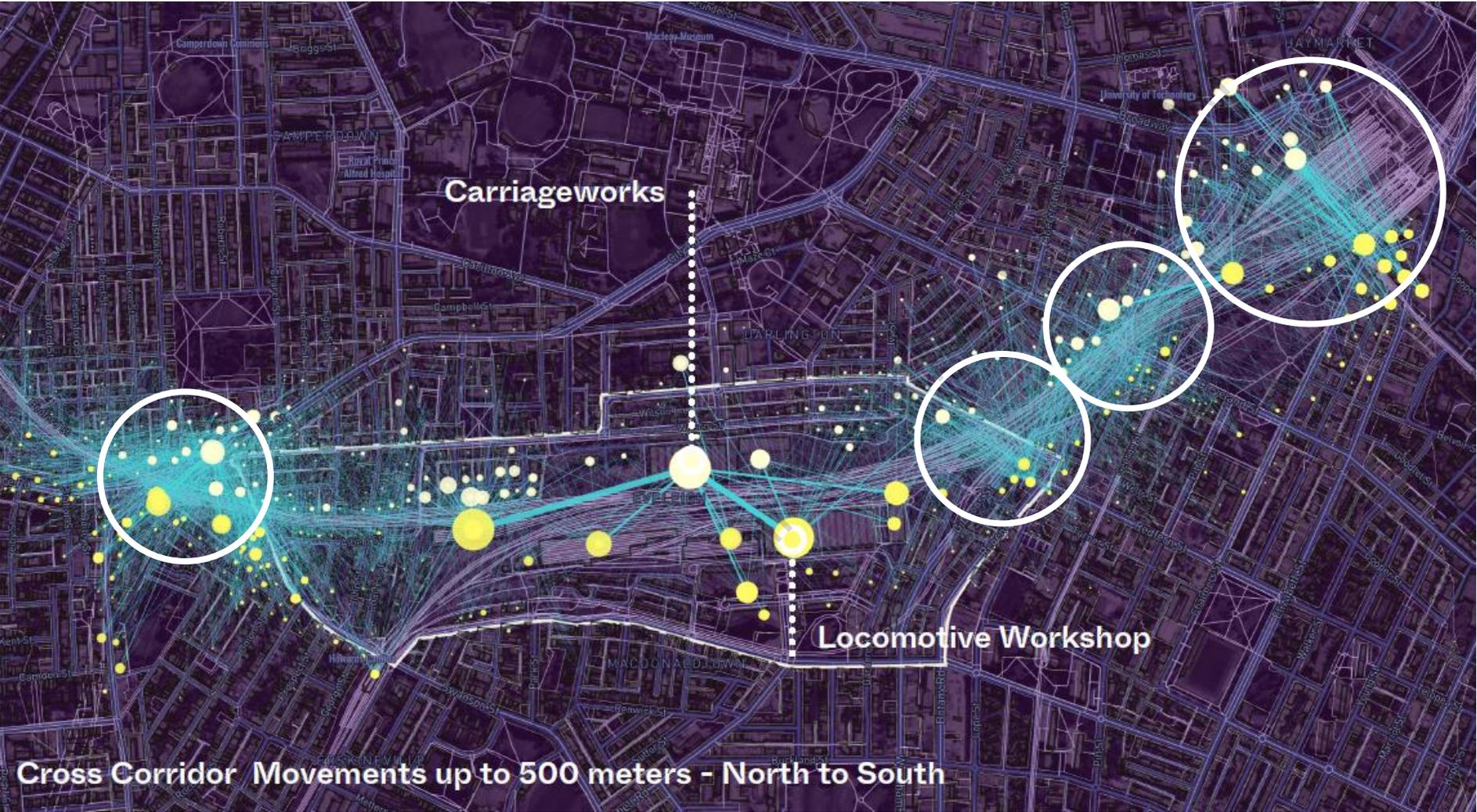
[03]



Role of Redfern-North Eveleigh development?

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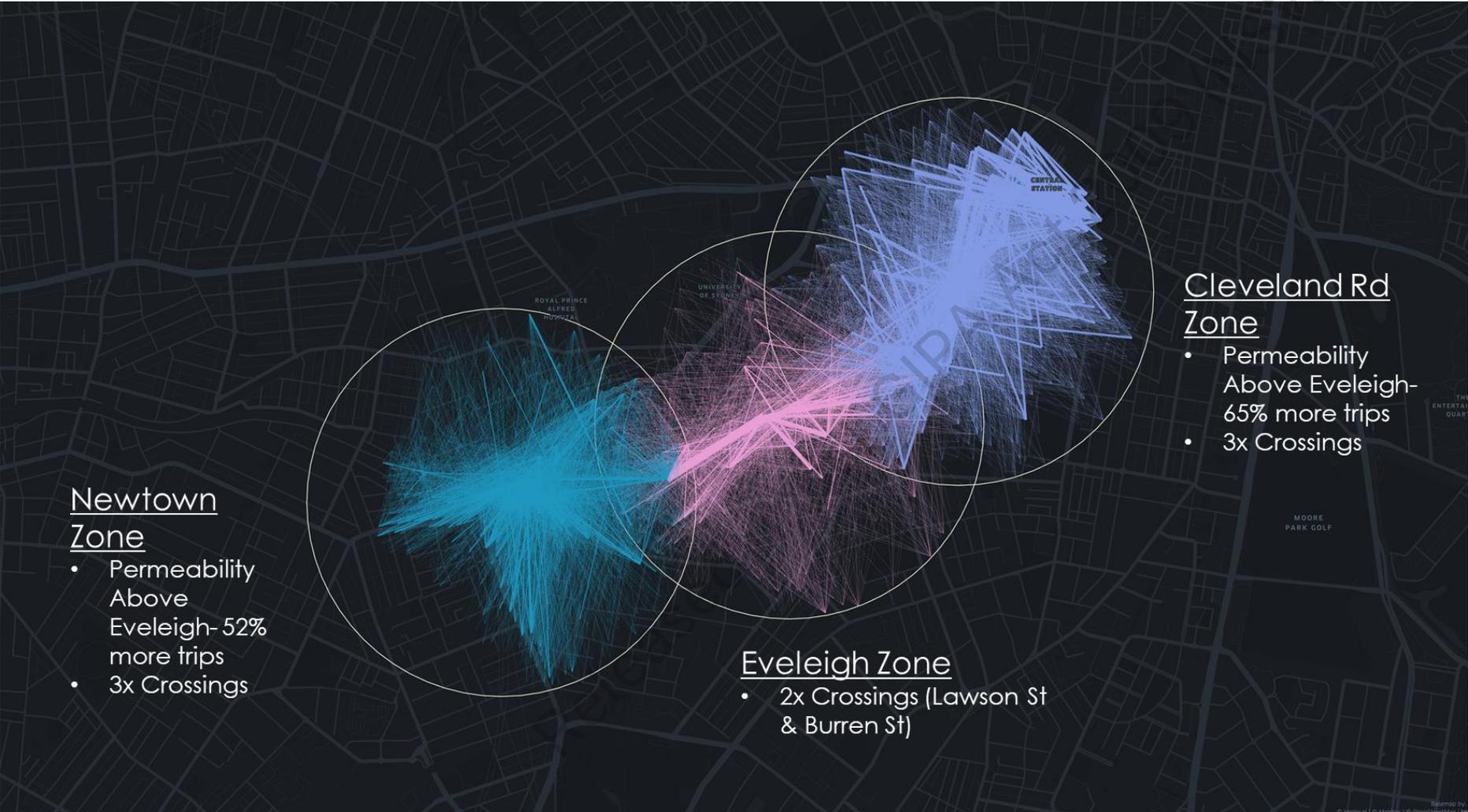
Increased activity due to attractions



Observed activity due to generators and attractions either side of the rail corridor (with a nearby crossing).



Increased activity due to attractions



Conservative assumption for uptake in activity

+10% to +25%

Based on observed activity in adjacent regions.

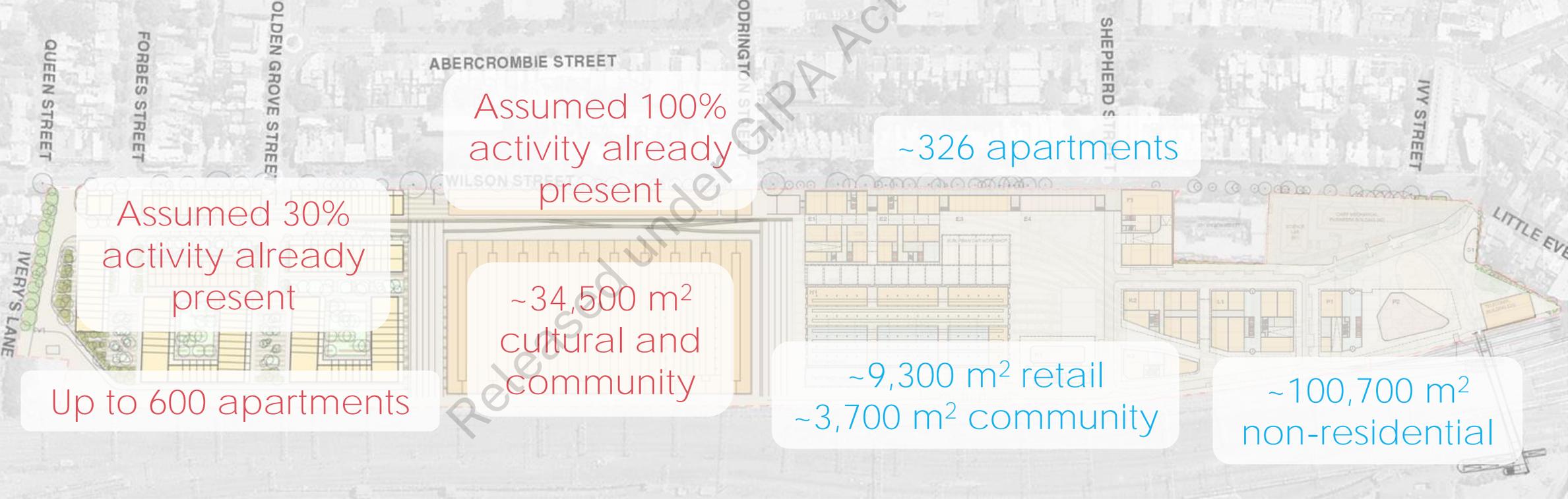


Increased activity due to land-use uplift

Proportion of Redfern-North Eveleigh precinct will utilise the bridge. Bridge may be used for access to and from the precinct and recreational purposes including lunch breaks to move between attractions at either the north or south precinct.

+10-20% of RNE precinct daily population

(includes customers who would use the bridge multiple times per day – with current 10-20% walk mode share for the precinct)



[04]



Outcomes

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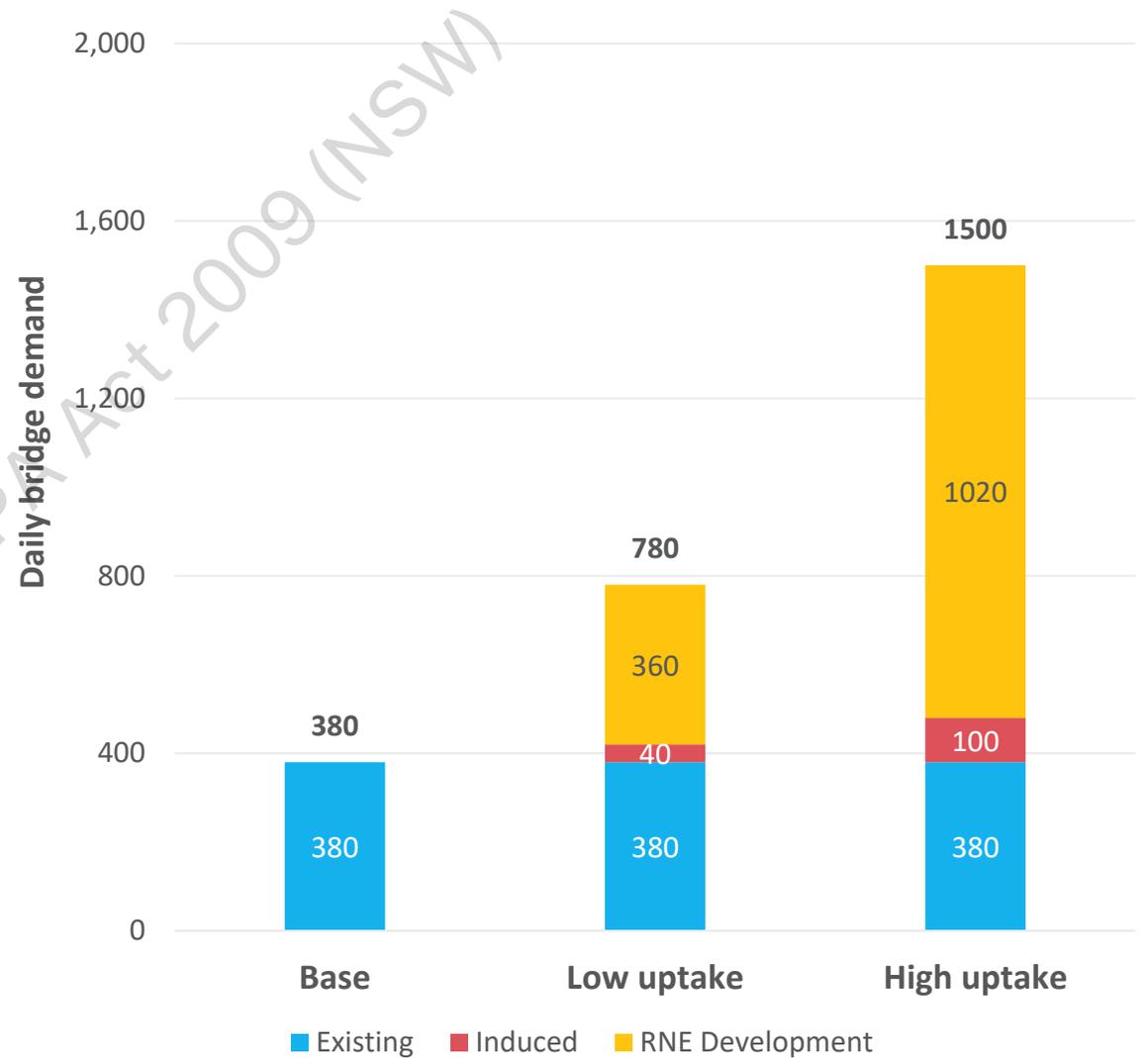
Potential bridge users

Induced demand:

- Increased permeability between generators and attracts
- Lower level of activity either side of rail corridor compared to regions like Newtown

RNE development related demand:

- Single largest contributor to use. Daily count includes an estimate for trips to and from the precinct.
- Assumes the proposed bridge is the most attractive option for:
 - 100% of residential, community and cultural land-uses.
 - 70% of commercial land-use. Some high-density commercial is located on the eastern edge which is closer to the southern concourse, making the proposed bridge less attractive for these customers.
- Assumes precincts are being established as self-serving for residents and employees.
 - If land-uses are linked between RNE and South Eveleigh we would expect more daily trips.

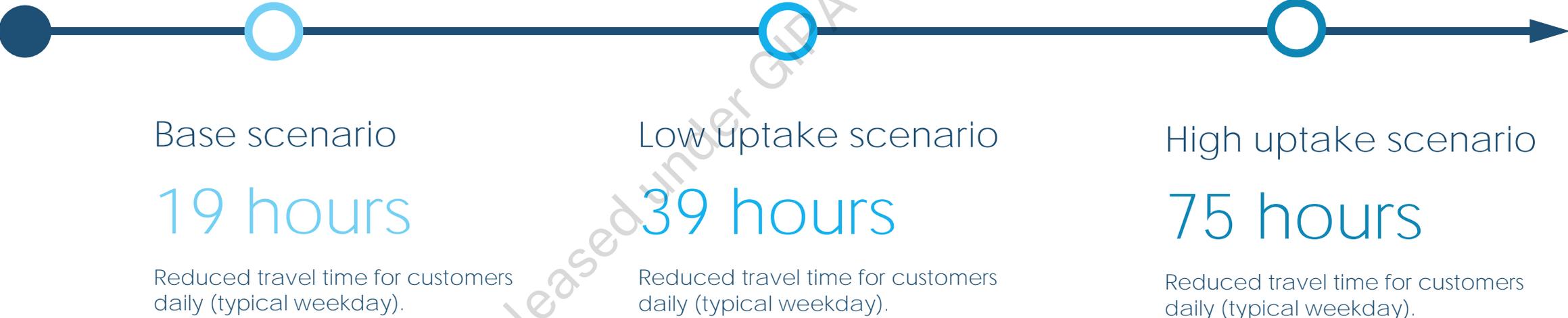


Potential benefit – daily productivity

Average travel time saving

3 minutes

per cross-corridor journey.



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Redfern North Eveleigh Bridge

Transport for New South Wales

Constraints Review

Rev 1

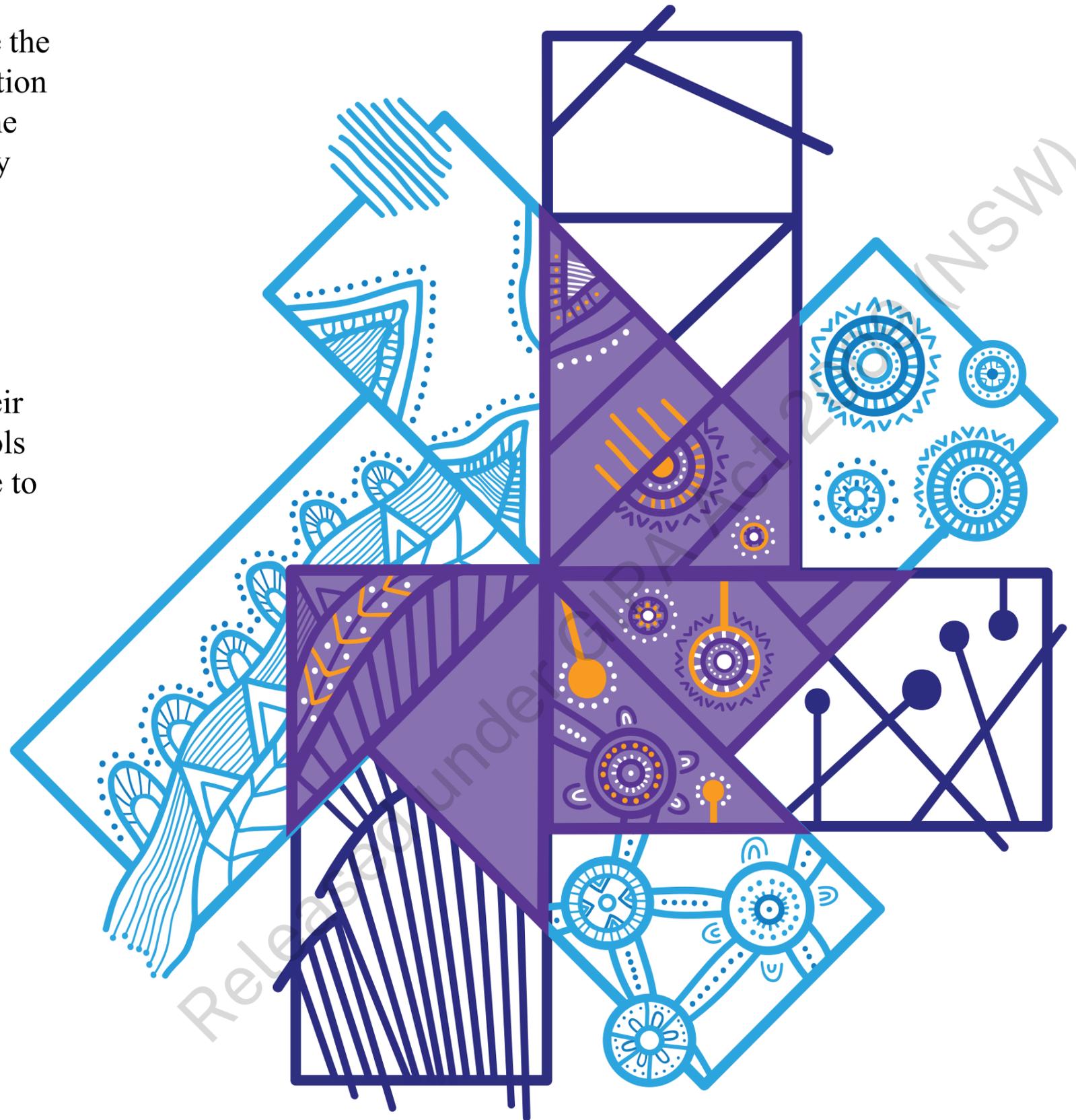
25 November 2022



We would like to acknowledge the Gadigal people of the Eora Nation as the Traditional Owners of the land on which the Arup Sydney office is located.

We pay respect to Elders past, present and emerging.

We recognise and celebrate their cultures, traditions and protocols and the contribution they make to the life of our city and beyond.



Reconciliation Action Plan

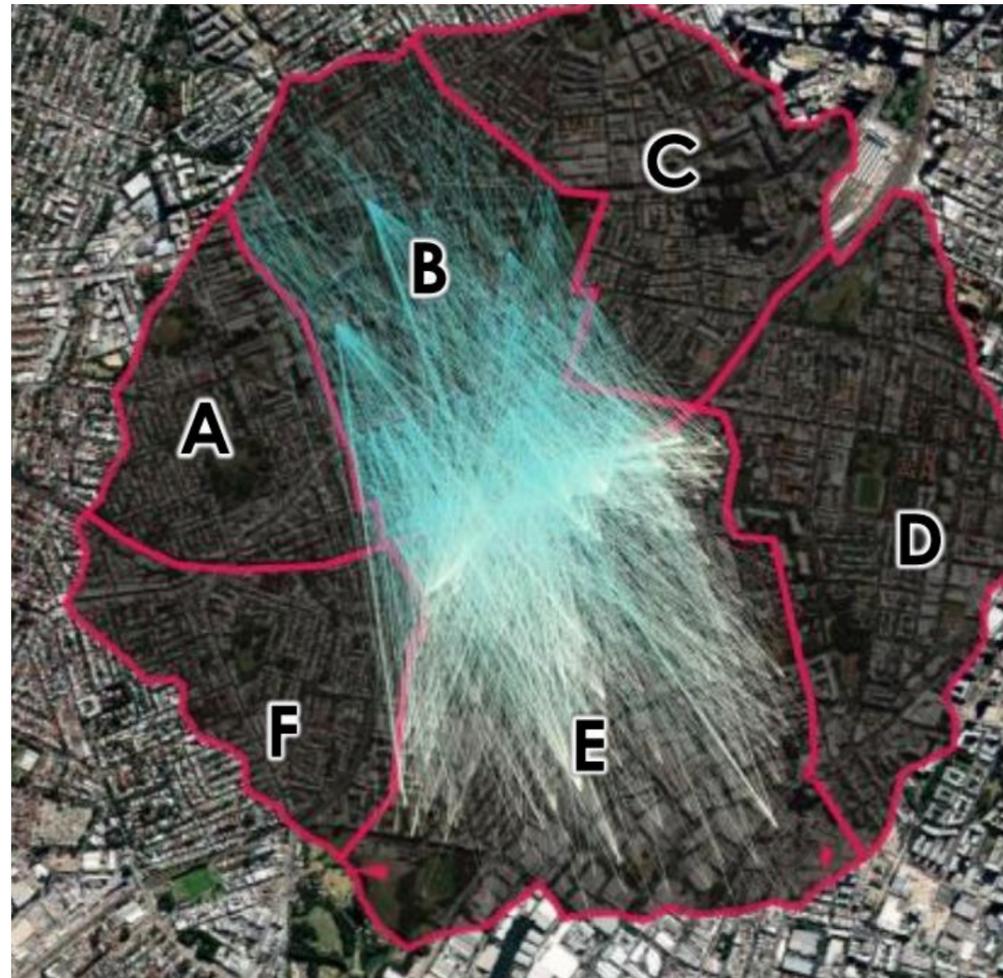
Relationships, Respect and Opportunities

↓ [Discover more on arup.com](#)

Overview

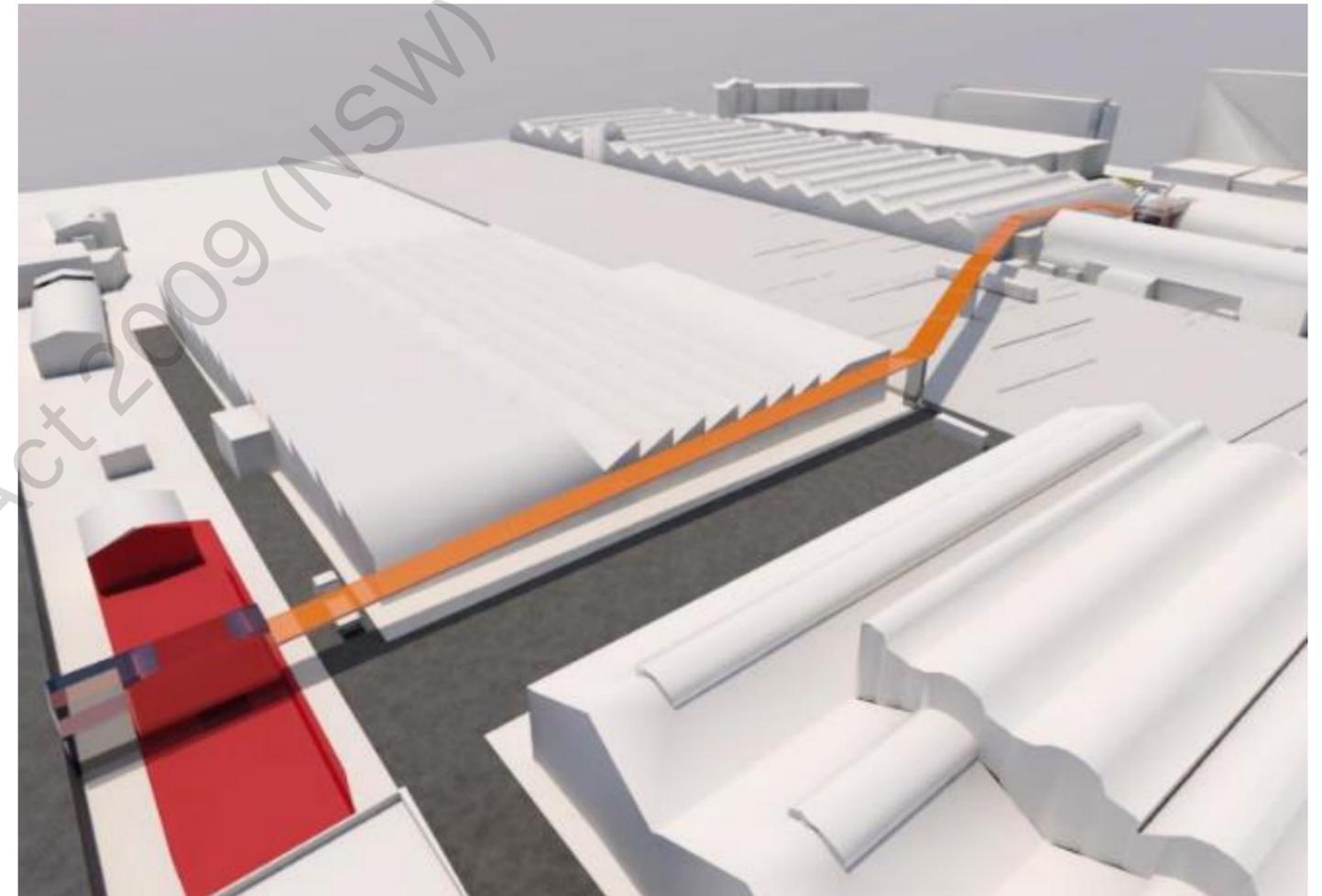
Objective

To investigate the feasibility of a bridge that connects RNE to South Eveleigh and enables pedestrian and cyclist patronage by considering constraints, design requirements, bridge form, risks, opportunities and future design development.



340-420 journeys per day during weekdays

Redfern North Eveleigh Paint Shop Precinct – Bridge catchment analysis, SCT Consulting, 2021



Option from previous study

Eveleigh Pedestrian Bridge, TZG , 2017

Contents

Review of Previous Studies

Overview of Constraints

Design Requirements

Structural Form

Next Steps



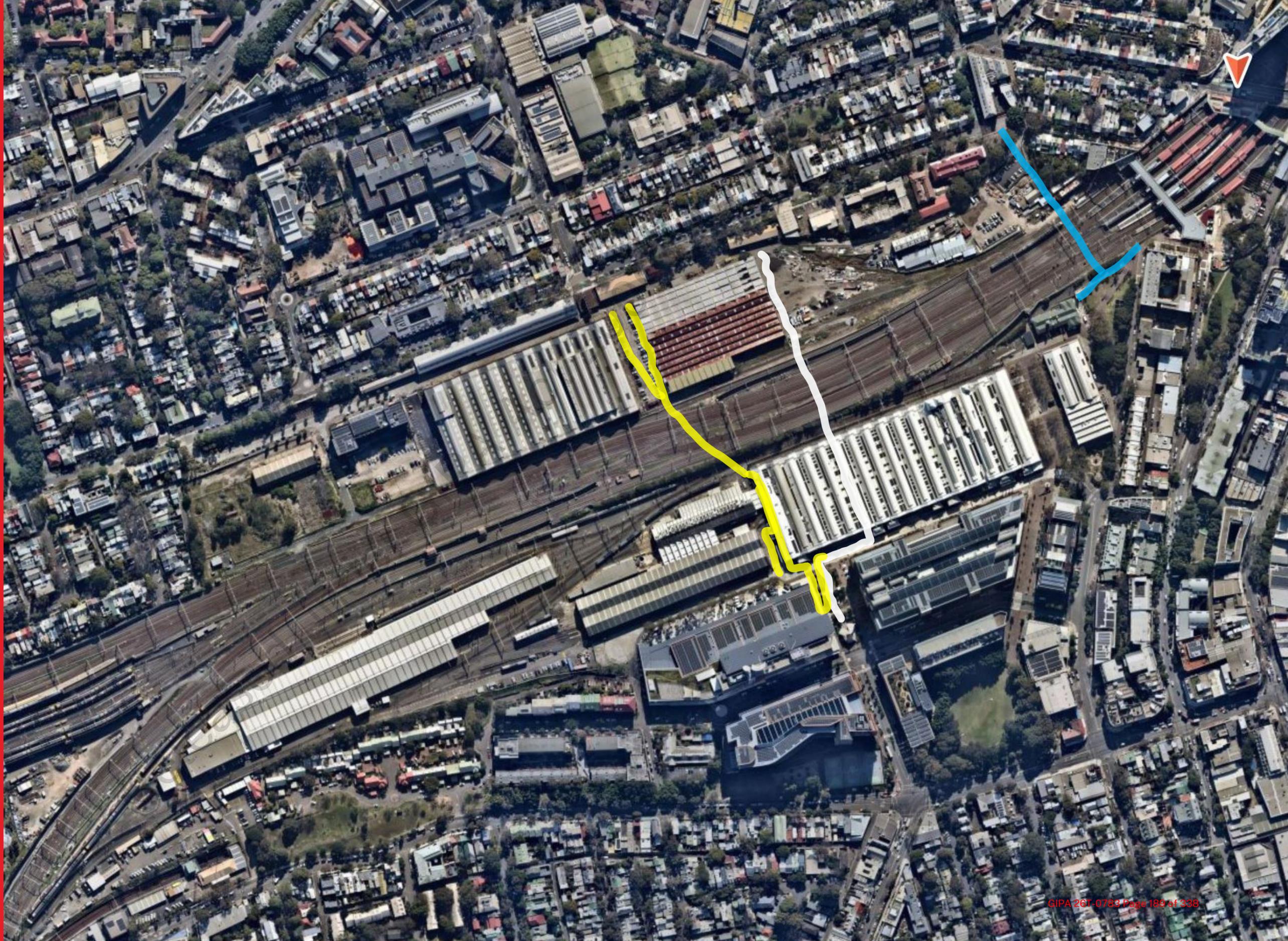
Review of Previous Studies



Eveleigh Heritage Walk Report for Redfern Waterloo Authority [2008]



Carriageworks to Australian Technology Park – North-South Pedestrian Link for UrbanGrowth NSW [2017]



Summary

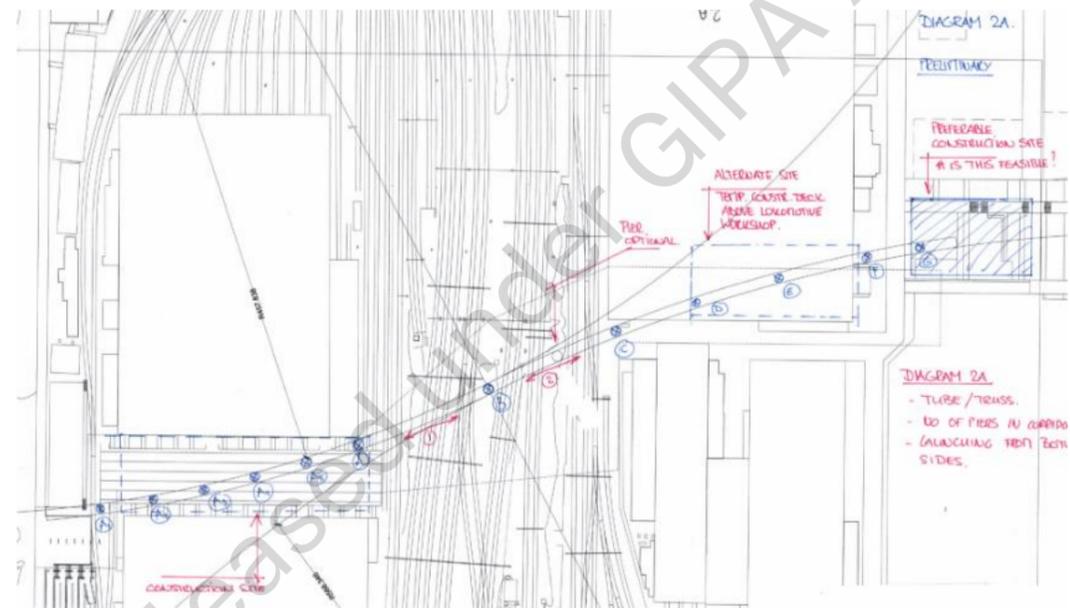
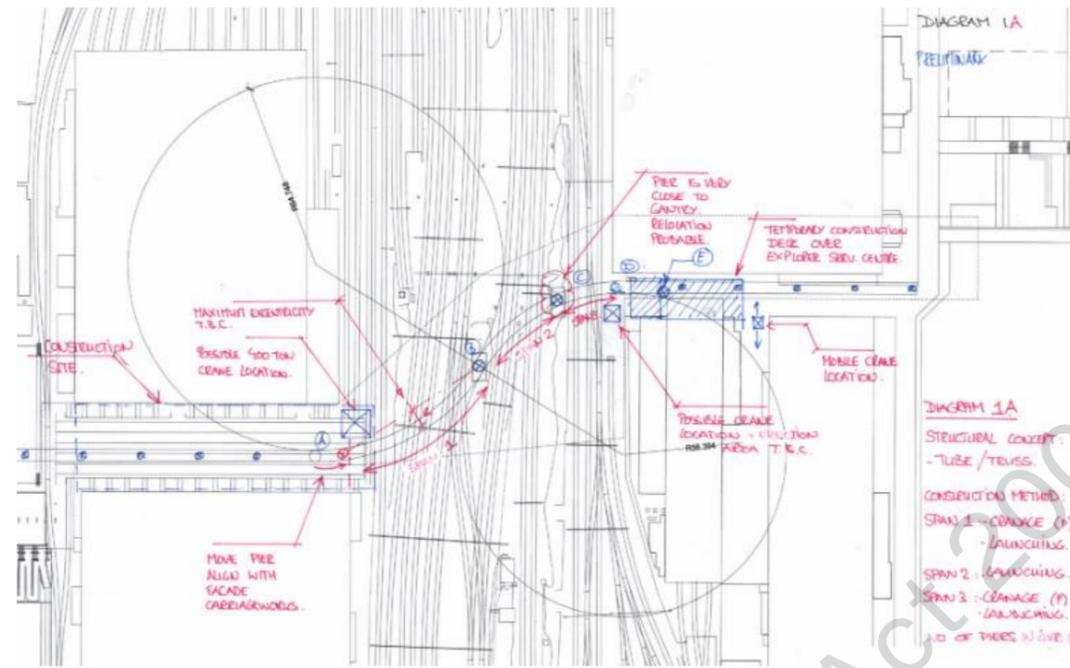
Multiple structural concepts were proposed, and some were developed into options in 2008 study.

Two preferred locations for bridge placement were considered:

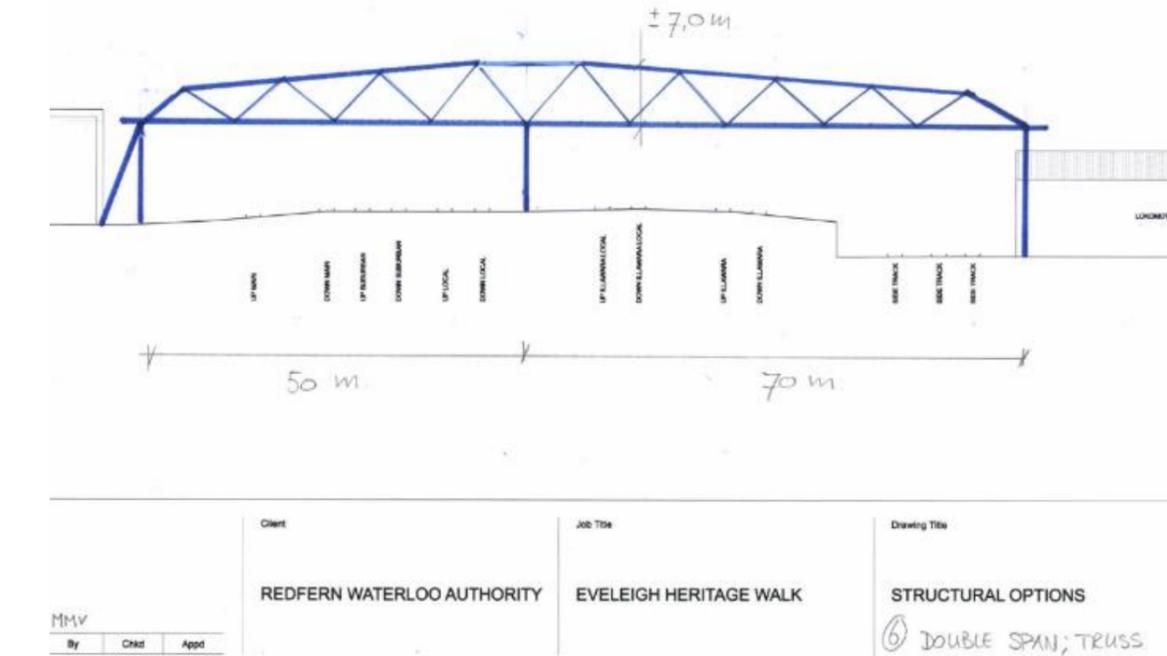
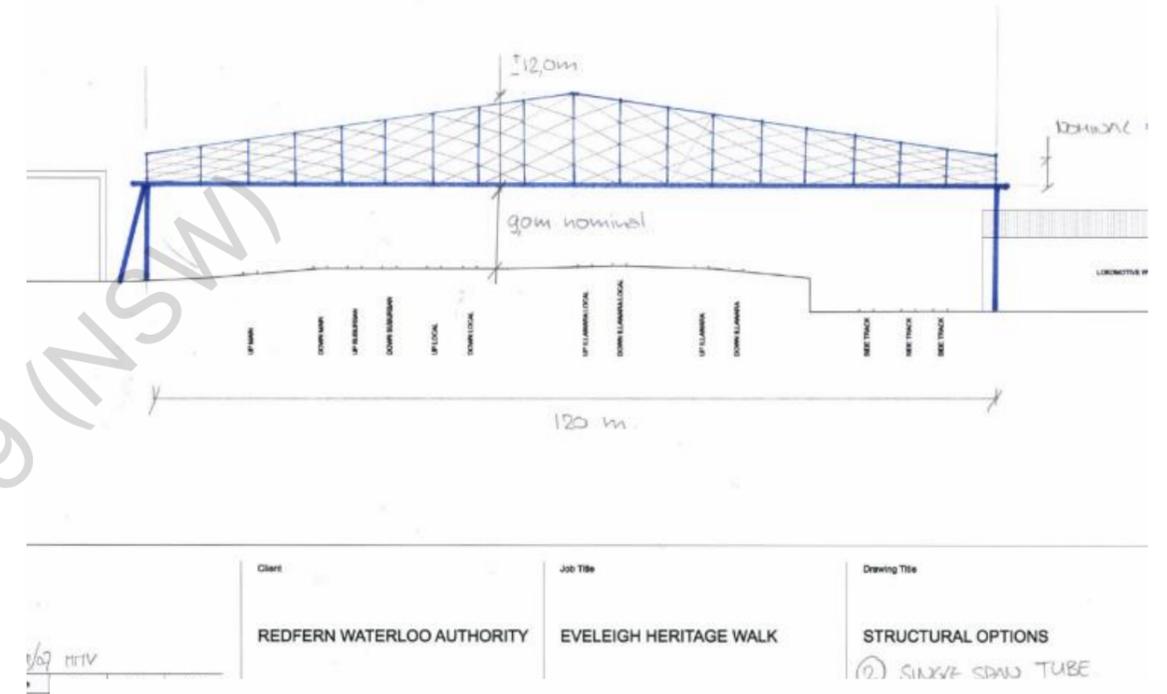
1. The north landing is at Eveleigh rail yard near Little Eveleigh Street, near the western end of the Redfern Station platform. The south landing is located at the Australian Technology Park (ATP) near Cornwallis Street.
2. Near Carriageworks and the stabling yard on the northern side of the railway line and the Locomotive workshop and LES building on the south

Second preferred location is in the same position as for this report.

Preliminary structural concepts and construction methodologies were presented in the 2008 study, however, the study focus was redirected to consider mostly options in the first location.



Example bridge design options for second preferred location in 2008 study



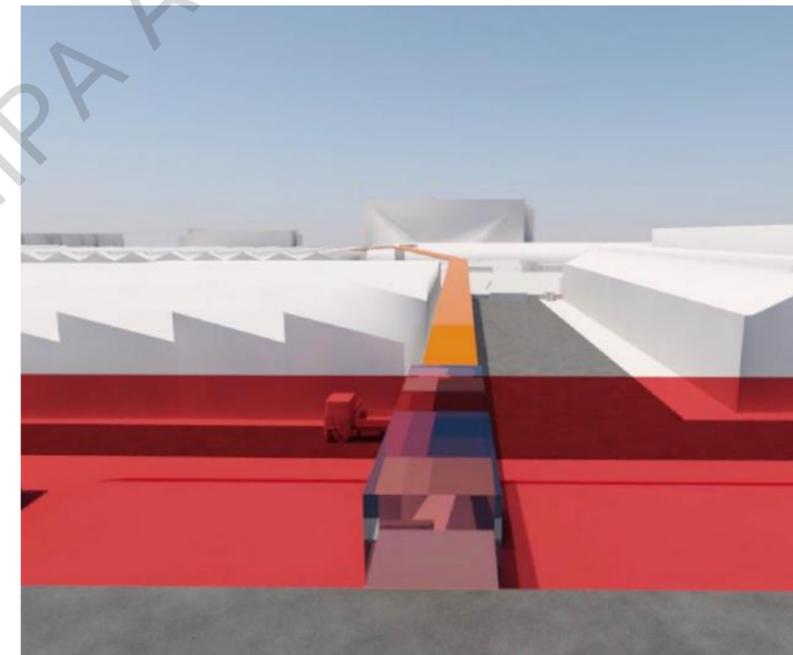
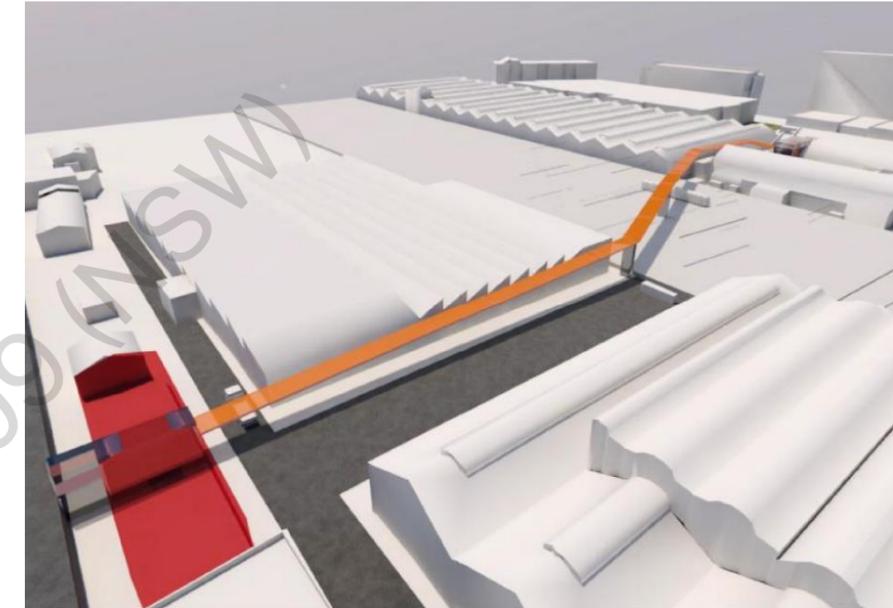
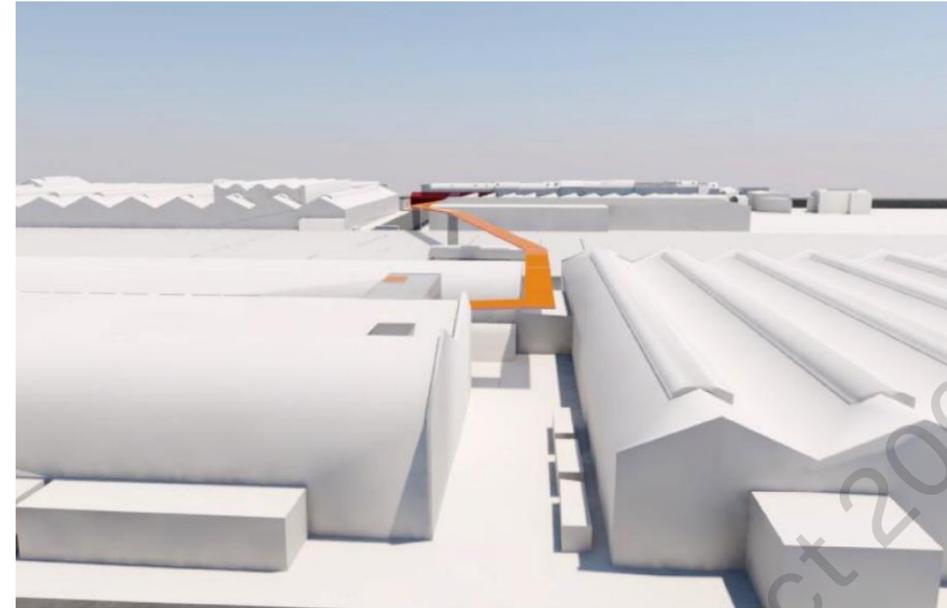
Example Structural Concepts

2008 Study

Eveleigh Heritage Walk

Summary

- Alignment options identified
- Known constraints identified
 - Heritage
 - Services
 - Geotechnical
 - Contamination
 - Possession
 - Eveleigh Yard Subway
 - Main West to CBD “exclusion zone”
- Structural forms presented
- Construction methods identified
 - Installed by crane
 - Launched with lateral
 - Rotation of both segments
 - Segmental construction
- Structurally feasible option presented
- Overall feasibility still to be determined



Renderings of Option 1c

2017 Study

Carriageworks to Australian Technology Park – North-South Pedestrian Link

Previous Studies

Optioneering Feasibility Study (2017)

Option 1a (Village Square)

- Segmental Construction
- 461m long (incl. ramps)

Option 1b (LocoB16)

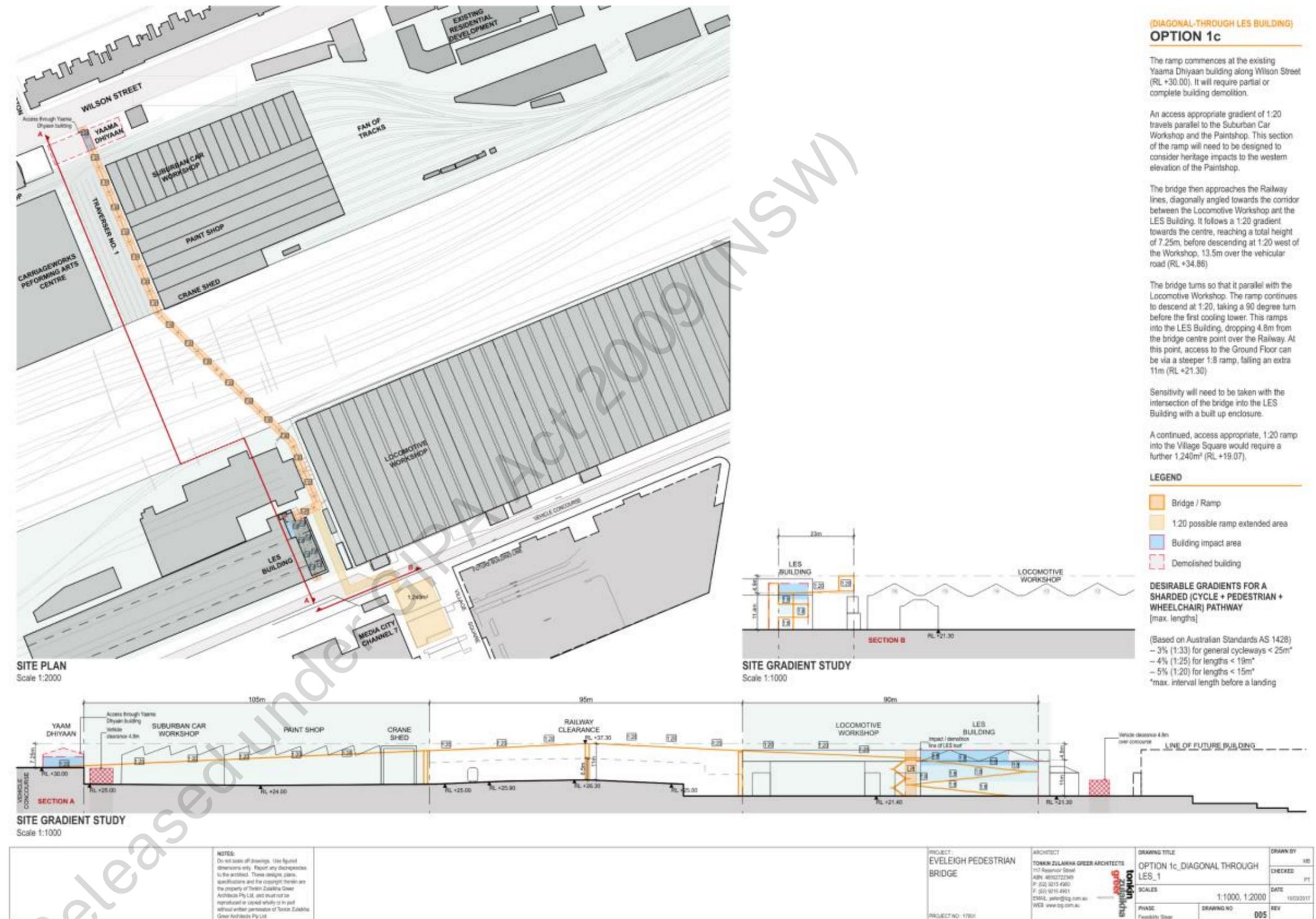
- Launched bridge
- 257m long (incl. ramps)

Option 1c (LES) – Preferred

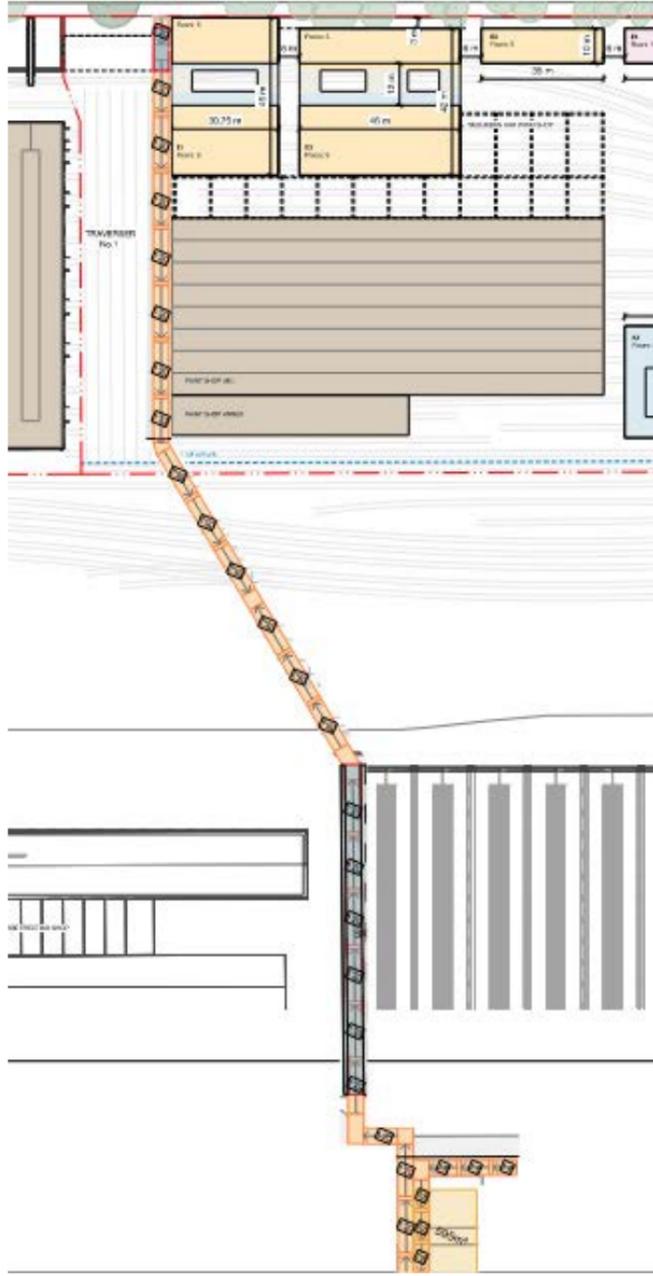
- Launched bridge
- 310m long (incl. ramps)

Option 4 (LocoB11)

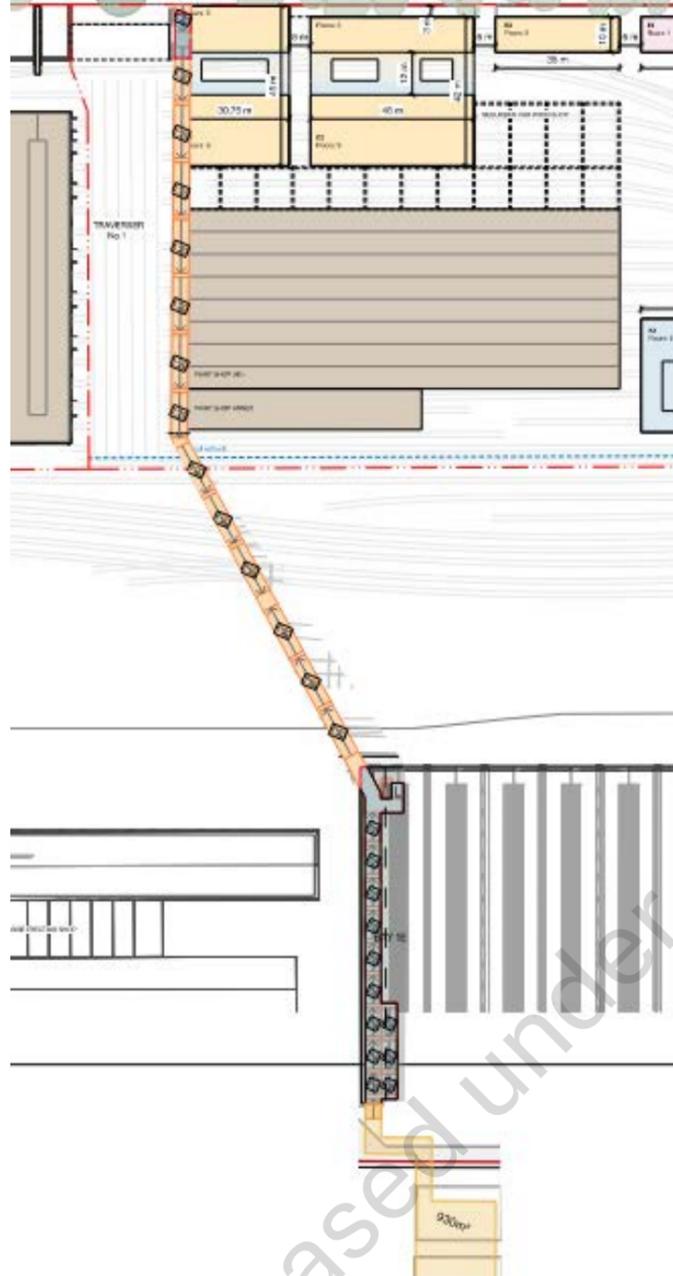
- Launched bridge
- 421m long (incl. ramps)



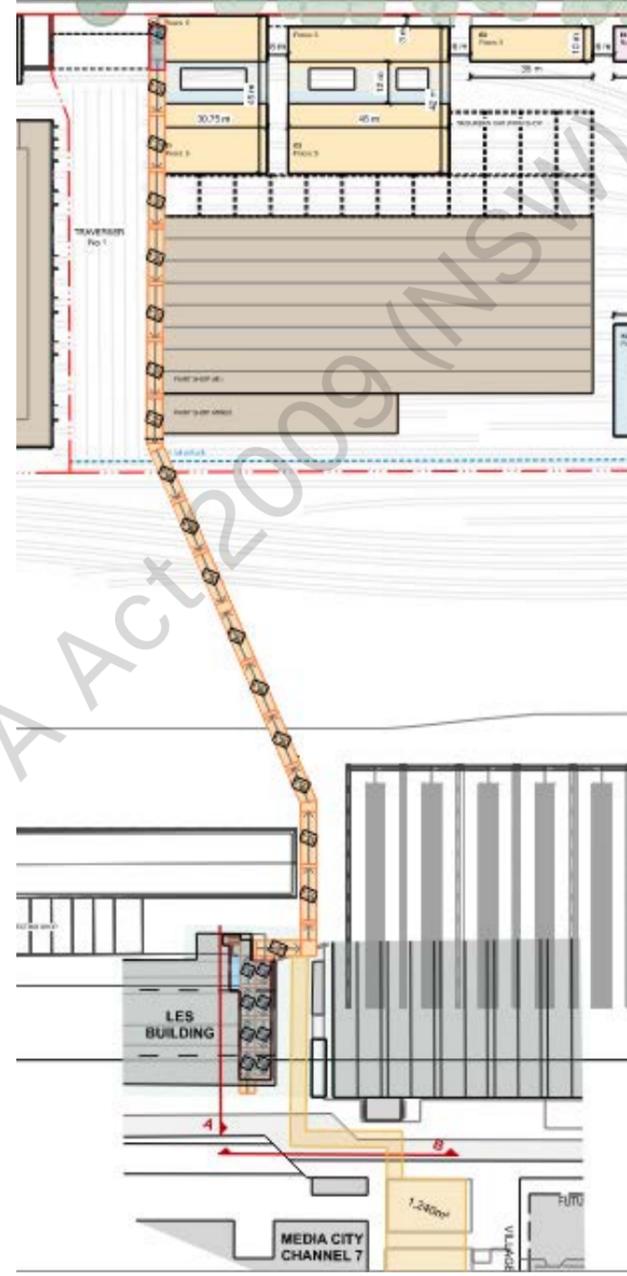
2017 Study



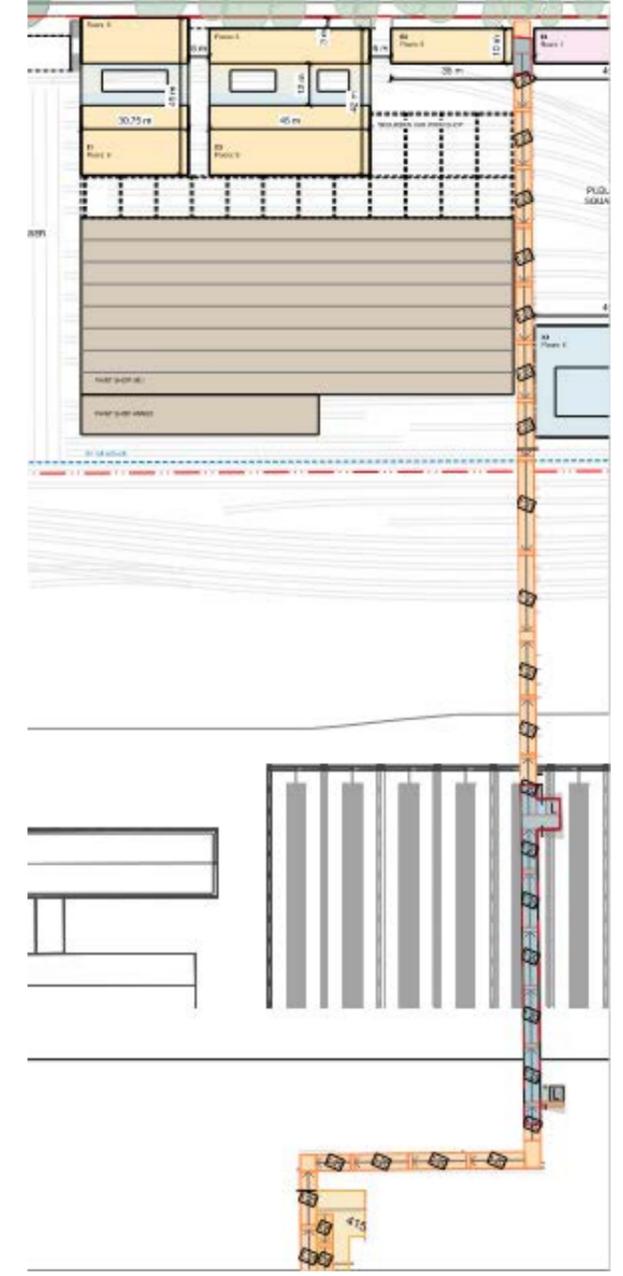
Option 1A



Option 1B



Option 1C



Option 4

2017 Options

Released under GIPA Act 2009 (NSW)

Constraints Overview

Rail Infrastructure

Drainage

Historical Maintenance Tunnel

Geotechnical

Contamination

Third Party Utilities

Heritage

Environmental

Topography | Property

Urban Planning



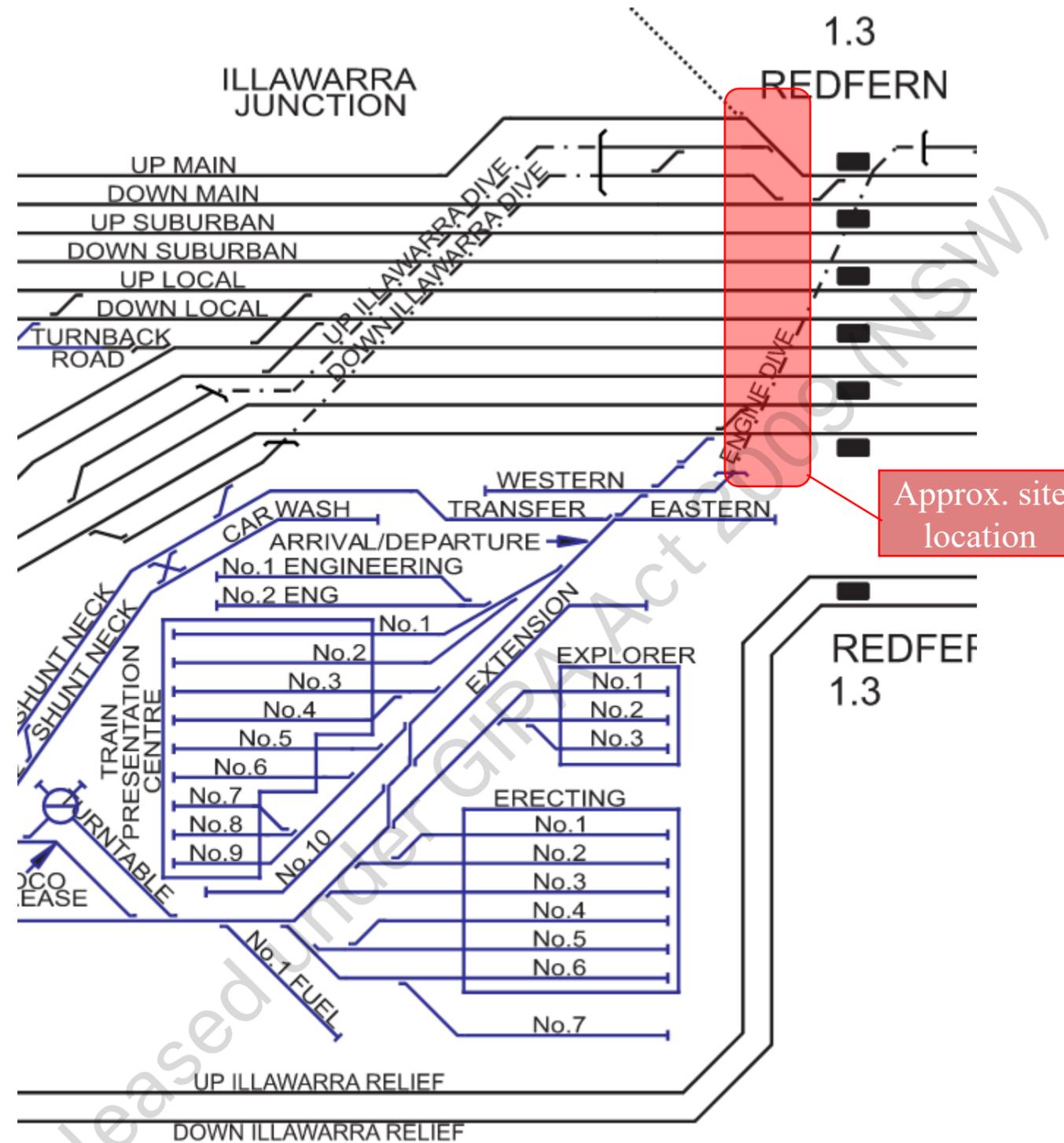
Rail Infrastructure

Redfern is a major heavy rail junction across a series of lines including:

- Western Lines (Mains, Suburban and Local)
- Illawarra Lines
- Access to the Eveleigh maintenance yards servicing the Explorer, Oscar and Intercity fleet, including the engine dive

Constraints

- Construction of the bridge will need to align with the possession configurations.
- Rail lines must remain fully operational. The bridge may need to remain in-situ partially constructed.



Indicative zone of bridge in red on the Metropolitan Network Diagram V3 TfNSW Config Diagram (2010)

Constraints Overview

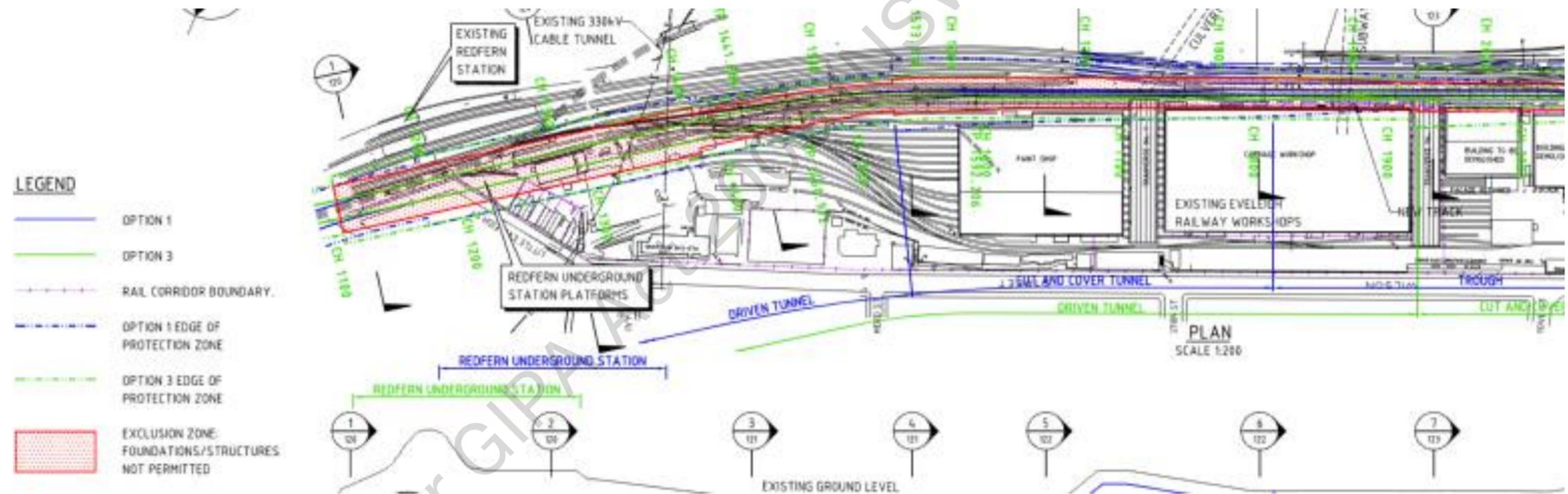
Current Heavy Rail Lines

Rail Infrastructure

Future Main West Line connection to CBD with future underground station at Redfern.

Constraints

- Exclusion zone where foundations are not permitted, directly within proposed landing zone.
- The corridor protection may be now redundant as it is understood that was the precursor to the now under-construction Metro West Line. This will need to be confirmed.



Main West Line to the CBD - Exclusion and Protection zones
Confidential – Not for Distribution

Constraints Overview

Future Main West Line

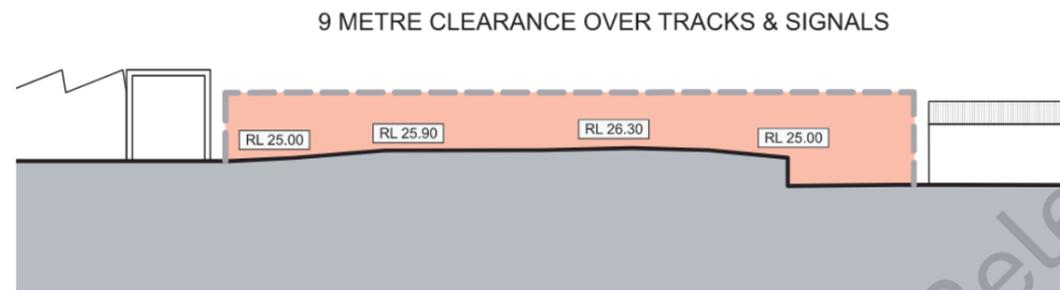
Rail Infrastructure

There are significant numbers of OHW and signal gantries along the rail corridor. The design and construction must consider the physical constraint of the existing assets.

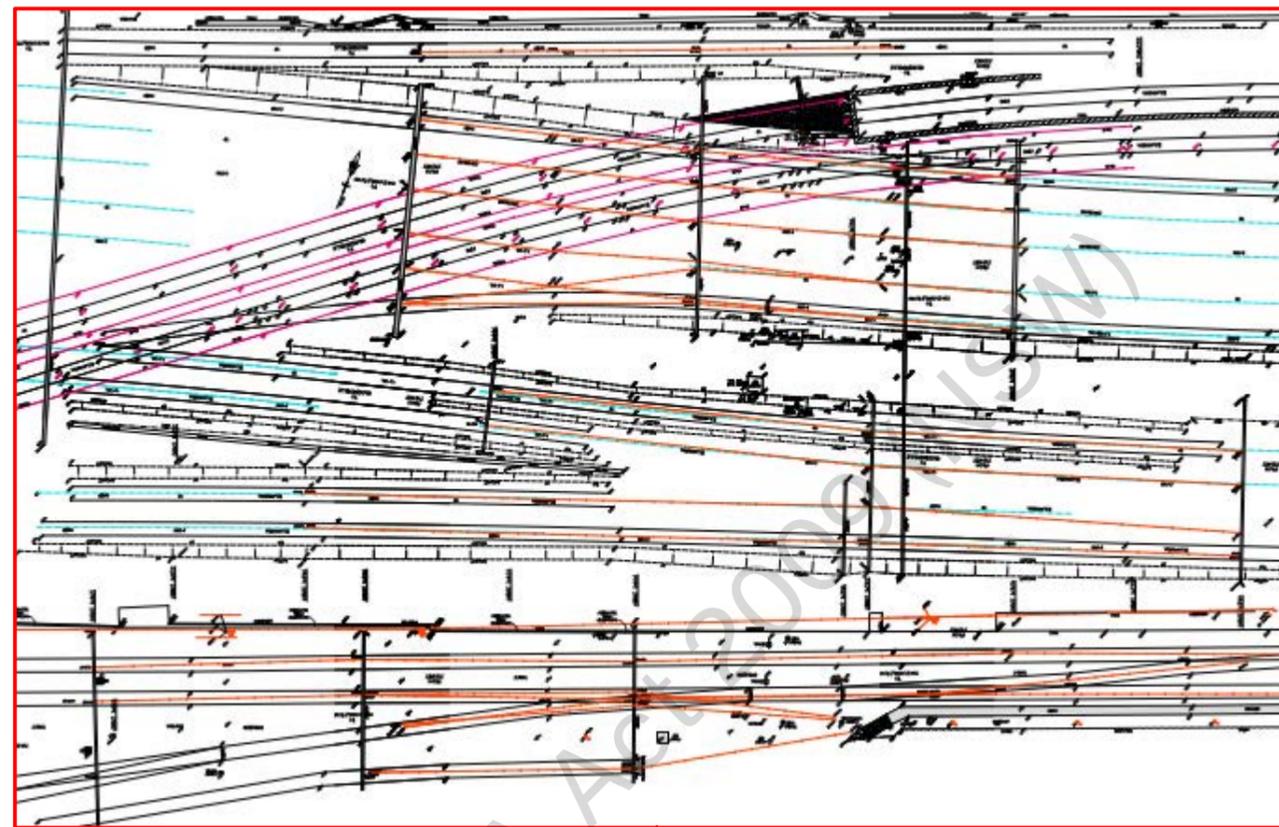
RWA Brief Document – Part D Project Brief in 2007 specifies a minimum clearance of 9 metres above the railway tracks to allow for future flexibility of installing overhead wiring structures. We believe this clearance requirement can be challenged.

Constraints

- Clearance from OHW and gantries governing the bridge deck level
- Consider earthing and bonding requirements (typical cost to bond structure)



Cox sketch (2017) – Section at Rail Corridor



Survey at Eveleigh (2007)

LEGEND :-	
+21.59	DENOTES SPOT LEVEL.
+24.12TW	DENOTES TOP OF WALL LEVEL.
+21.56BW	DENOTES BOTTOM OF WALL LEVEL.
+34.85TOP	DENOTES TOP OF FEATURE LEVEL.
+28.33CAT	DENOTES CATENARY WIRE LEVEL.
+26.88CON	DENOTES CONTACT WIRE LEVEL.
+34.83W	DENOTES WIRE LEVEL.
+34.16MID	DENOTES MID WIRE LEVEL.
+20.19	DENOTES TUNNEL LEVEL.
+24.45R	DENOTES ROOF OF TUNNEL LEVEL.
PP O	DENOTES POWER POLE.
LP *	DENOTES LIGHT POST.
BLR	DENOTES BOOT LEG RISER. (EARTH POT)
KC	DENOTES KRONE CABINET.
I	DENOTES STANCHION.
—	DENOTES TRACK ALIGNMENT.



Google Map (2022)

Constraints Overview

Current Overhead and Signalling Configuration

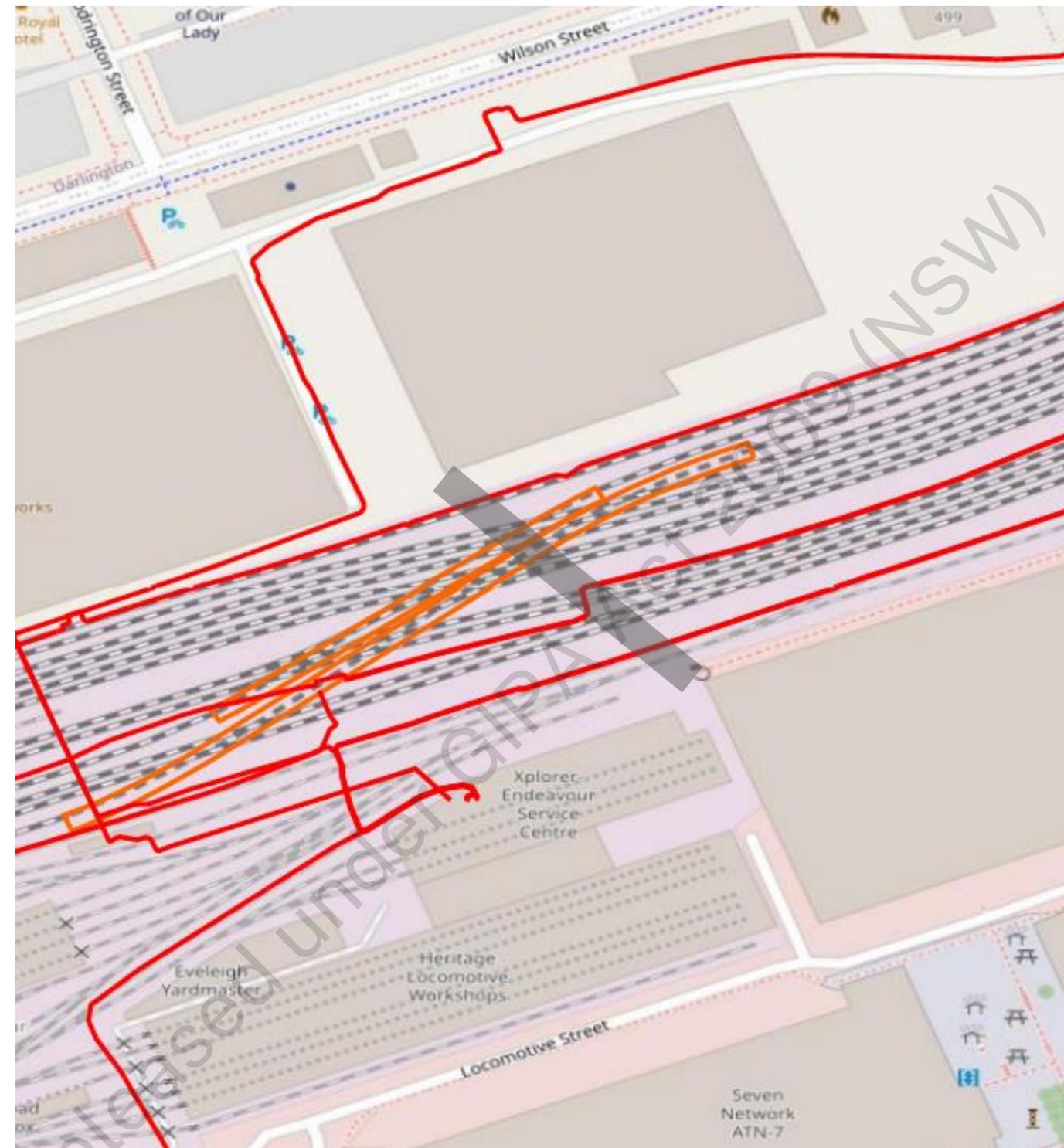
Rail Infrastructure

Sydney Trains active assets in the area, identified in Dial Before You Dig (DBYD) search in the area:

- HV cable
- Illawarra Dives (Tunnel)
- Potential for other underground services

Constraints

- Works are not undertaken within 5 metre radius of any RailCorp electrical, communication assets, and within 25 metres of any other RailCorp tunnel and/or Airport Line tunnel, according to the current RailCorp DBYD Terms and Conditions.
- These constraints impact on the placement of pier and foundation location across the rail corridor and the Traverser at North Eveleigh.



Sydney Train – Before You Dig Australia Location Information (2022)

LEGEND:

- | | | | |
|---------------------------------------------------------------------------------------|-------------------------|---------------------------------------------------------------------------------------|----------------|
|  | Affected BYDA Work Area |  | HV Cable |
|  | Tunnel |  | Communications |

Constraints Overview

Current underground Rail HV

Drainage

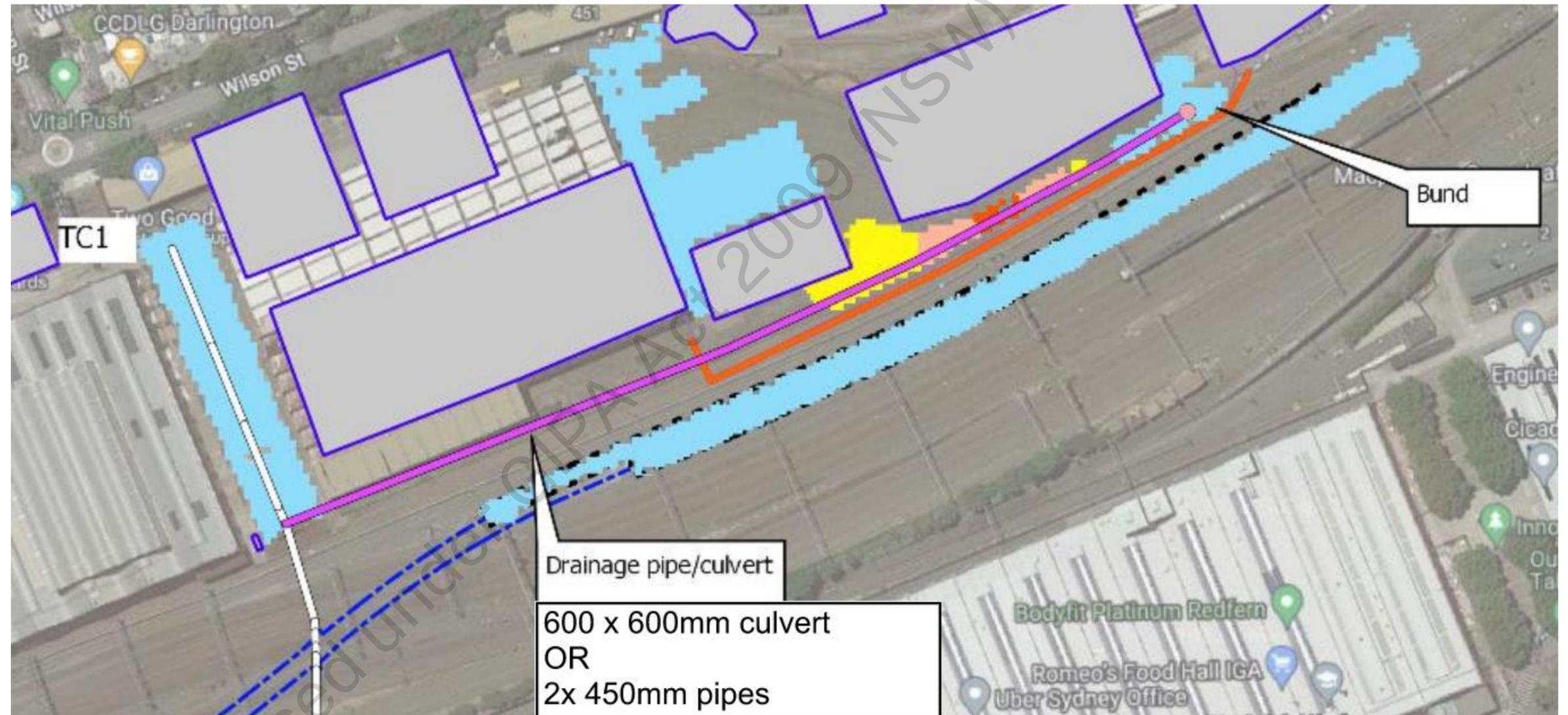
Sub-Surface Drainage

The AECOM flooding report proposes a <900mm deep, ~600x600mm or twin 450mm dia trunk drain along the southern edge of the paint shop precinct. A new 250 dia pipe and pits are also proposed to the south of the paintworks as part of the MTMS2 works. This is a potential landing zone for the piers of the northern approach ramp.

An existing drainage culvert (TC1) runs the length of the traverser.

Overland Drainage

Ballasted track relies on efficient drainage to prevent ponding and degradation of track. The placement of any piers should consider impacts to drainage.



1% AEP Impact map with proposed mitigations, AECOM Water Quality, Flooding and Stormwater Assessment (SSP Study No. 13) 60660346-RP-IU-01

Constraints Overview

Drainage Current | Proposed

Existing Maintenance Tunnel

Eveleigh Yard Subway

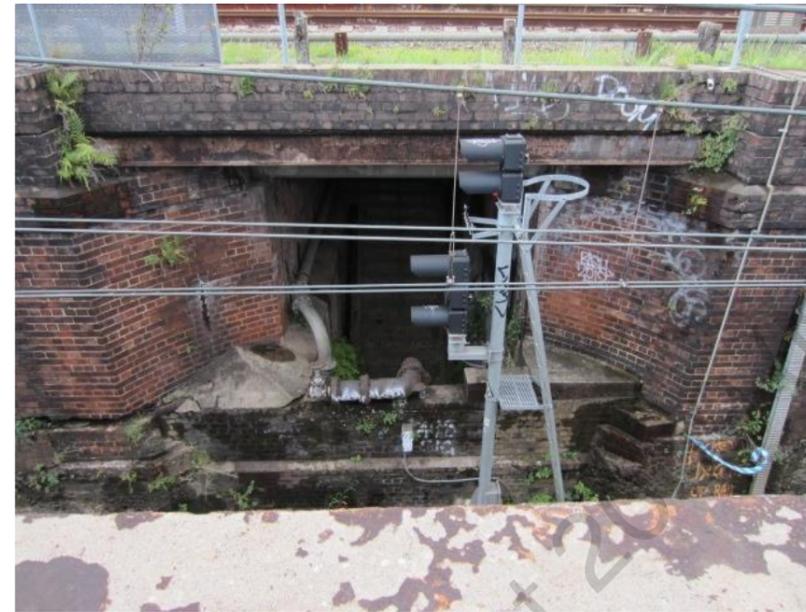
A 'tunnel' was indicated diagrammatically and described briefly in various sources of drawing and reports, running approximately along the alignment drawn from the west end of the LES building to the south centre of the Carriageworks building, but not the entire length.

The NSW Office of Environment & Heritage provides the following description under Eveleigh Railway Workshops, listed under s.170 Register.

Heritage Description: S34: Eveleigh Yard Subway (1925-1927): The subway is a rectangular tunnel 80 metres in length, running below the rail tracks between the Carriage Workshops and the Loco Workshops at Eveleigh. Walls are brick lined and the floor and ceiling are concrete. Both ends are accessed by a flight of brick steps from ground level and there is one flight of steps within the tunnel, near the southern end.

Constraints

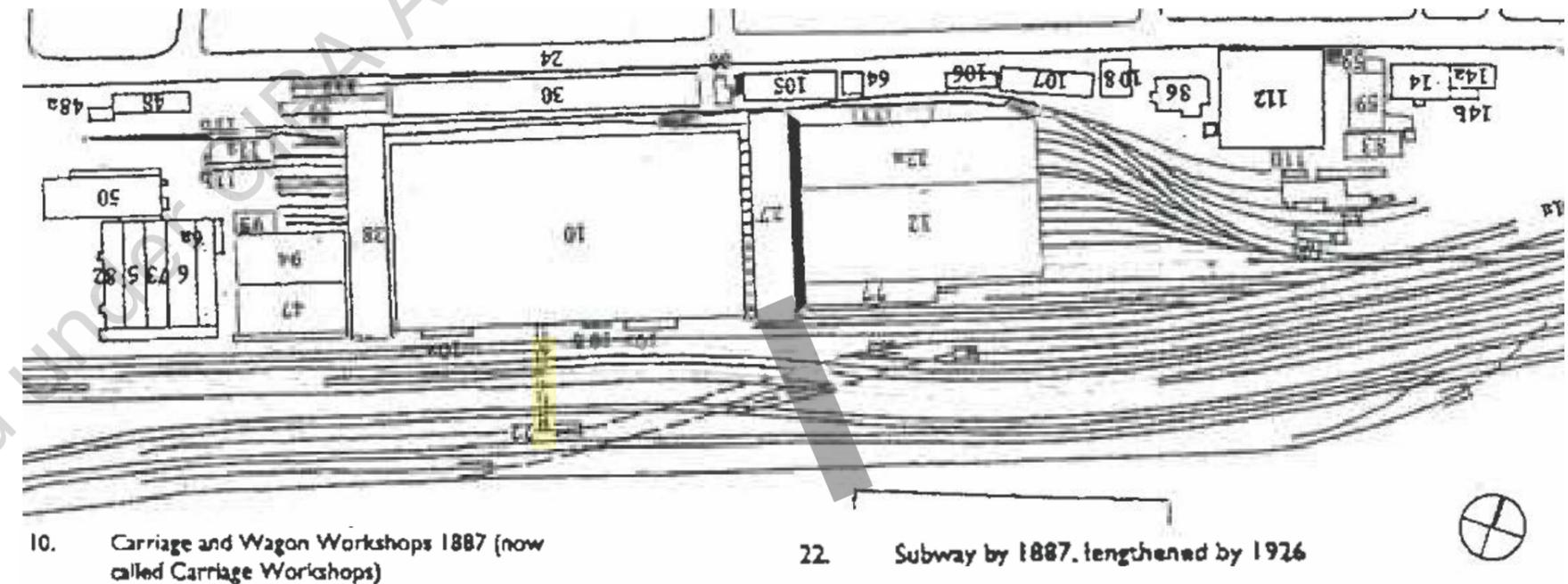
- Although the subway has the potential for access of workers, materials and equipment into the required construction zone between tracks during the construction of piers or temporary support, its use would be limited by the operation of railway above.
- The tunnel may be considered as confined space, pending on further investigation of the site setting.



NSW Office of Environment & Heritage website



Eveleigh Carriageworks – Conservation Management Plan Volume 1



Statement of Heritage Impact - Carriageworks at Eveleigh Contemporary Performing Arts Centre (2003)
Subway location (Image placed upside down for North pointing upwards)

Constraints Overview

Existing Subsurface Access Tunnel

Redfern North Eveleigh to South Eveleigh Bridge

Geotechnical

Historical Geotechnical Investigations

Carriageworks

Jeffery + Katauskas 1998

→ 6m to Shale

South Eveleigh

Johnson Environmental Technology 1993

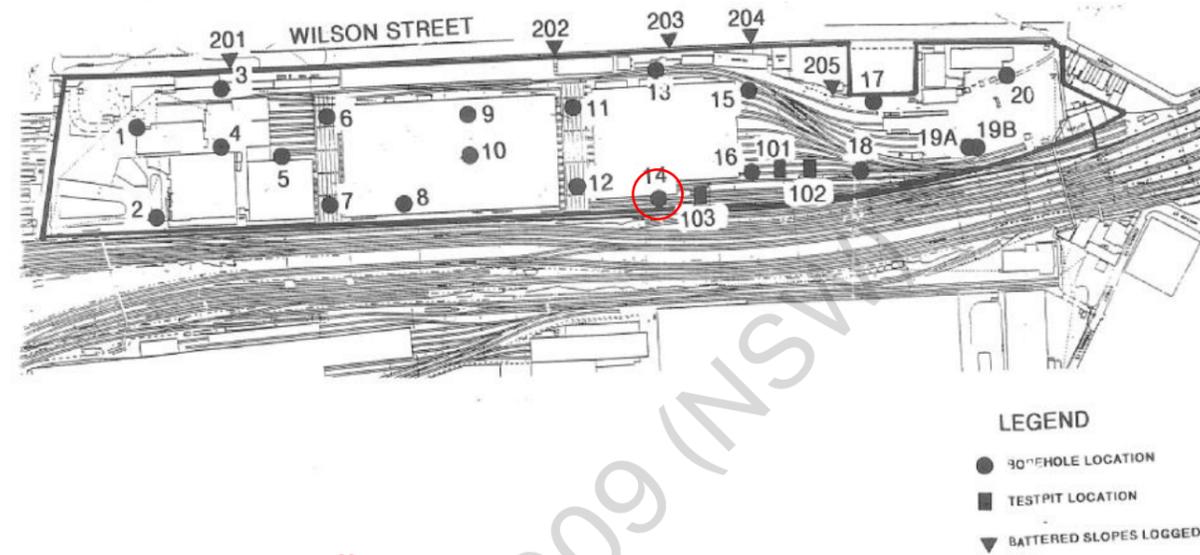
→ 8m depth of sands, no rock observed

Observations

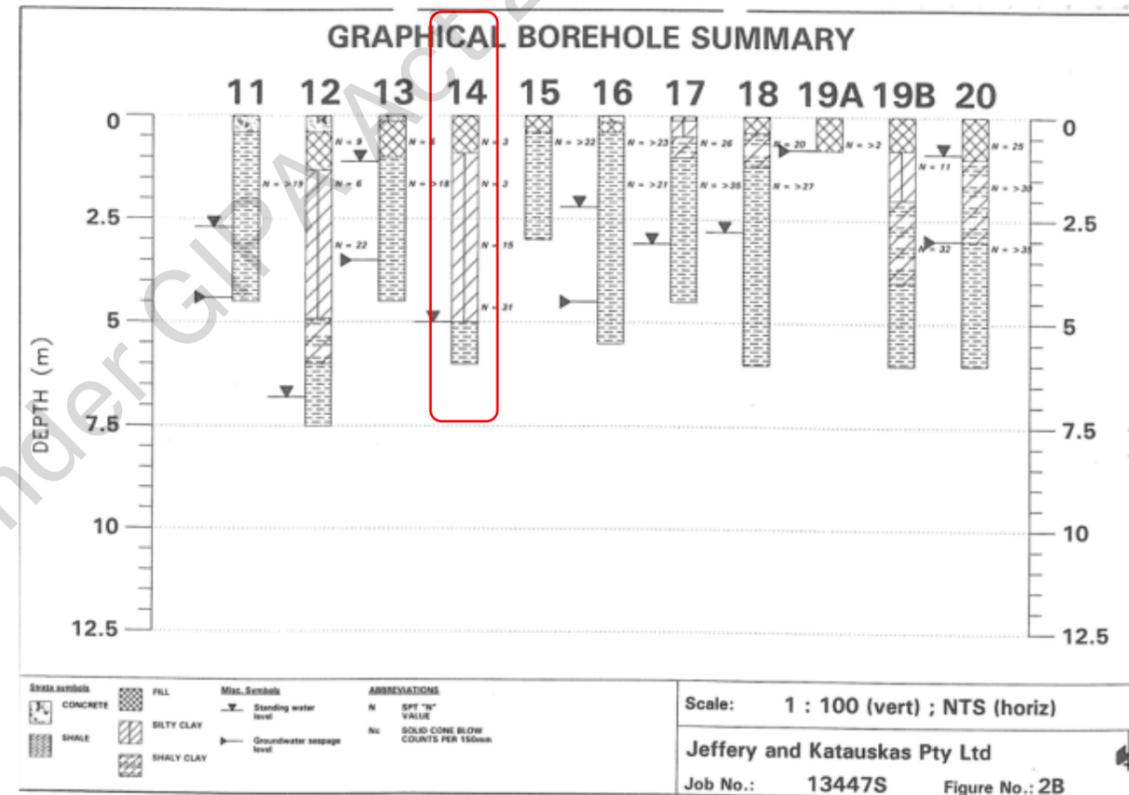
→ Driven or cast in place bored piles into shale is the likely solution for bridge foundations. Driven piles may not be acceptable given the noise and vibration produced by pile driving.

→ The design of midspan pier foundations in the corridor will likely be governed by rail collision loading.

→ The dimensions of the substructure to the midspan pier and deflection wall may not be compatible with the existing rail infrastructure.



Borehole locations, Jeffrey and Katauskas (1998)



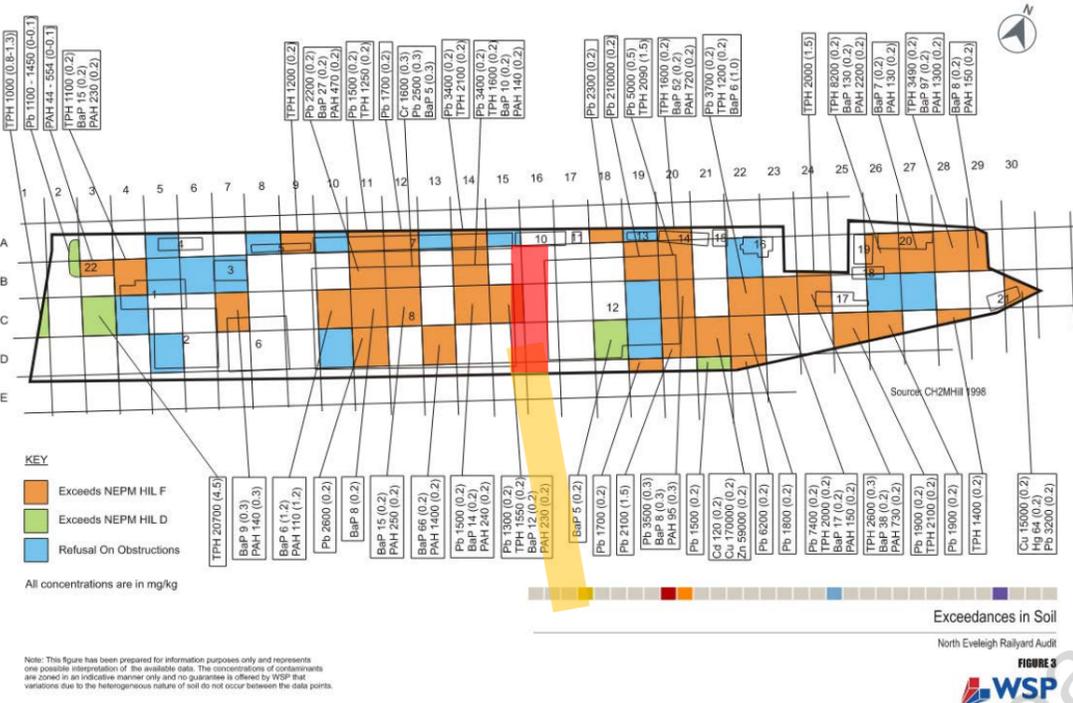
Borehole summary, Jeffrey and Katauskas (1998)

Constraints Overview

Historical Geotechnical Investigations

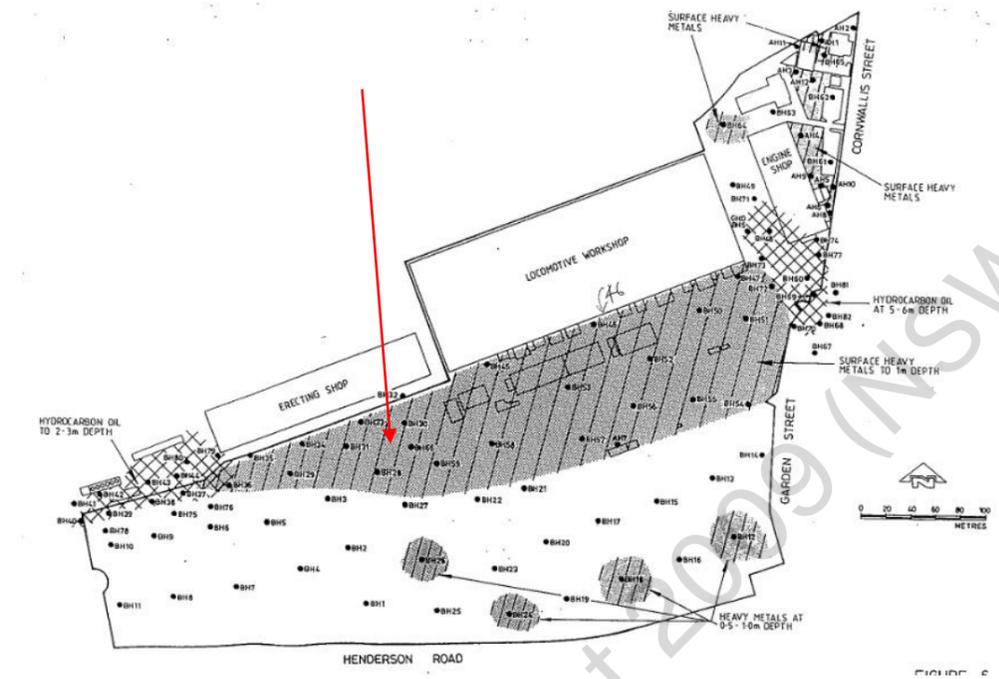
Contamination

The WSP Interim Audit Advice 1 in 2007 presented the Contamination study conducted in North Eveleigh Yard while contamination in South Eveleigh Yard was shown in the 1993 Johnstone Environmental Technology Report.

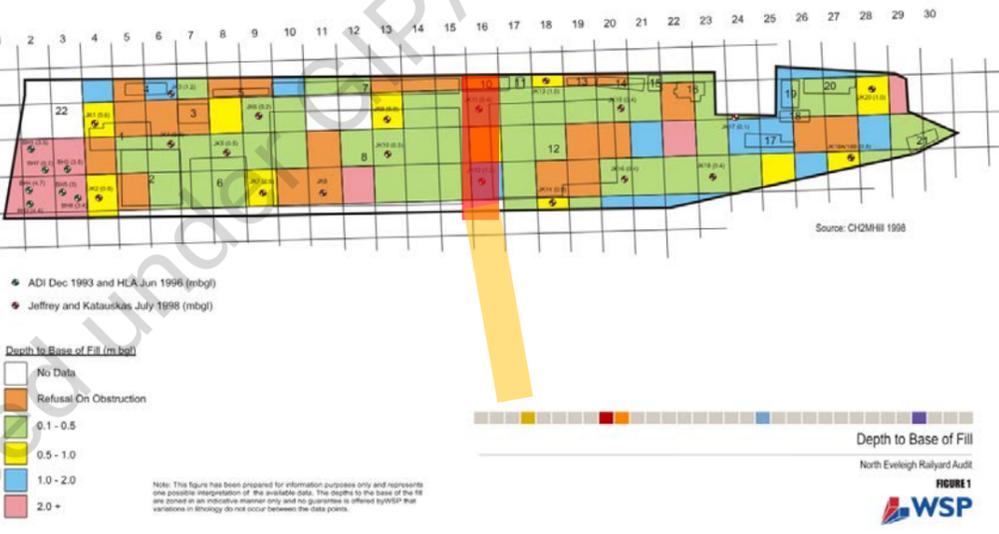


WSP Interim Audit Advice 1 (2007)
North Eveleigh - Contaminant Exceedances in Soil

- Traverser
- Proposed bridge location



Johnstone Environmental Technology Report (1993)
South Eveleigh Yard – pointing at BH66



WSP Interim Audit Advice 1 (2007)
North Eveleigh - Depth to Base of Fill

DRILL LOG

HOLE No.	ER BH66
Project	Eveleigh Railyards
Project Location	Redfern
Position	See Plan
Method of Drilling	Hollow Flight Auger
Date	19/5/93
Logged By	AL
Page	1 of 2

SPT	Depth (m)	Description	PID Readings
	0	Surface	
	0.0 - 2.2	ash FILL, non odorous	0.0ppm
2,2,2 N=4	0.0 - 1.0	ash FILL, non odorous	0.0ppm
2,2,4 N=6	0.0 - 2.0	ash FILL, non odorous	0.0ppm
1,2,1 N=3	3.0 - 4.0	layer of brown and yellow fine grained SANDS, moist, non odorous ash FILL	0.0ppm
1,1,2 N=3	4.0 - 5.0	yellow fine grained SAND, moist, non odorous brown fine grained SAND with patches of compressed dark brown sand	0.0ppm
3,3,5 N=8	5.0 - 6.0	yellow fine grained SAND, moist, non odorous	0.0ppm
	7.0	water table at 7.2m	
5,12,18 N=30	6.0 - 8.0	yellow fine grained SANDS, wet, non odorous	0.0ppm

JOB No. JET0224 JOHNSTONE ENVIRONMENTAL TECHNOLOGY PTY LIMITED

Johnstone Environmental Technology Report (1993)
Drill log from BH66

Constraints Overview

Historical Contamination Studies

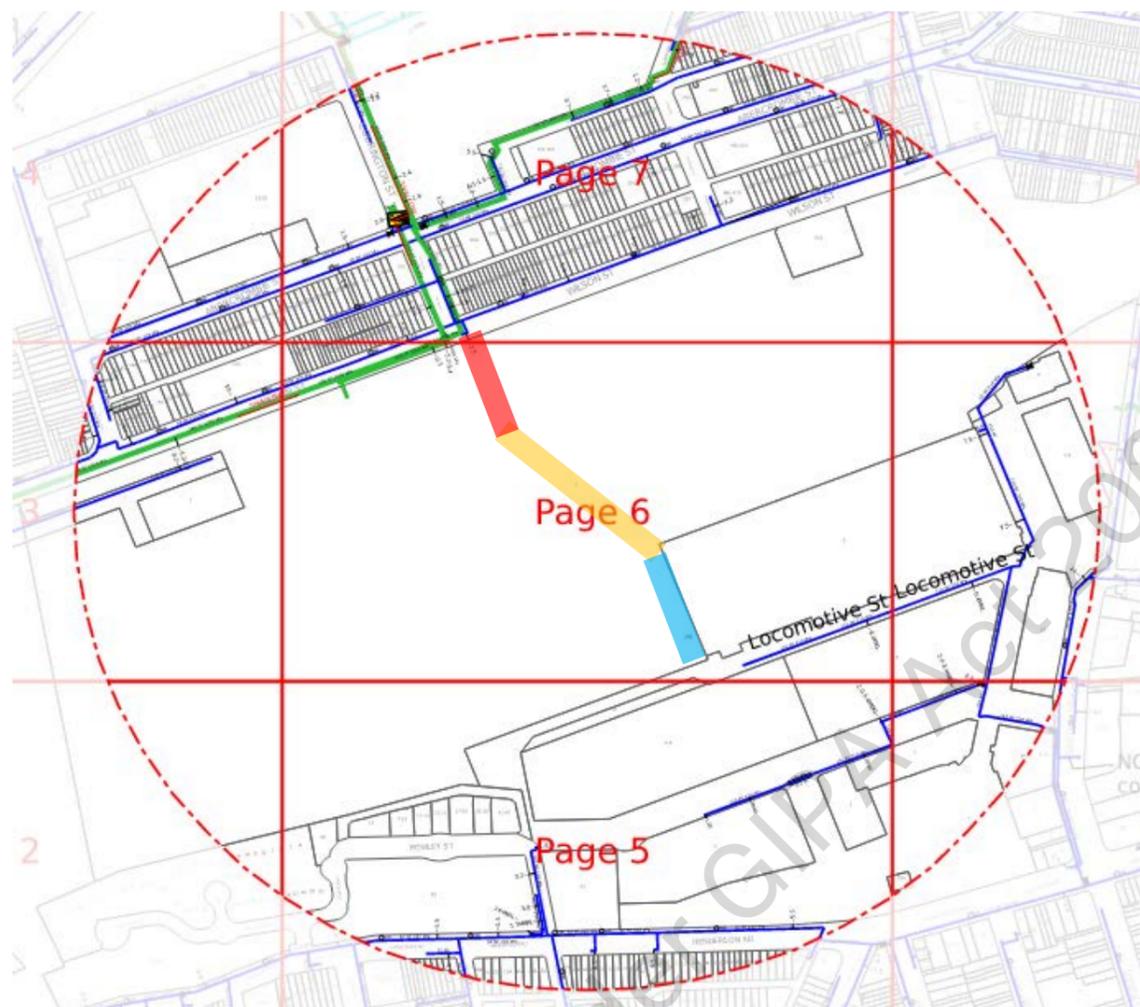
Third Party Utilities

The following assets are identified with the DBYD search in the area, including the vicinity of potential north and south landings as envisaged in the 2017 study. Assets are generally located near Yaama Dhiyaan building on Wilson Street at the north of Traverser (north landing) and near Locomotive Street on the south of the corridor between the Locomotive Workshop and the LES Building (south landing).

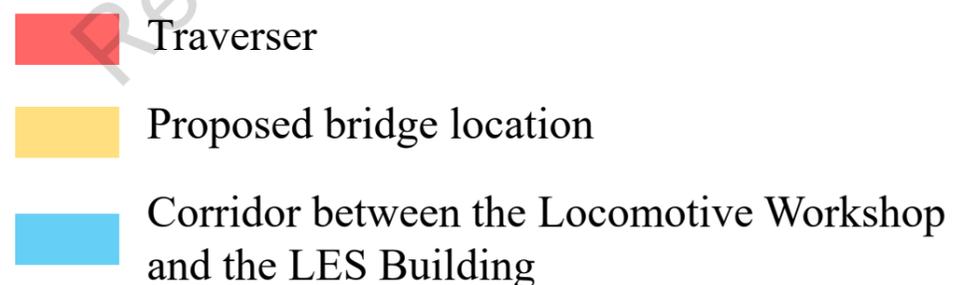
- Jemena
- Sydney Water
- Ausgrid
- City of Sydney
- NBN
- Potential for other underground services

Constraints

- Works may not be undertaken within the clearance set by the asset owner



Jemena DBYD



Sydney Water DBYD

Constraints Overview

Third Party Utilities

Heritage

Adjacent paint shop and annex is exceptional or high level of heritage significance.

Traverser machine must be preserved, either at the northern or southern end of the Traverser carriageway.

Ideally no structures obstructing the view from the heritage.



Paint shop and annex are heritage items.

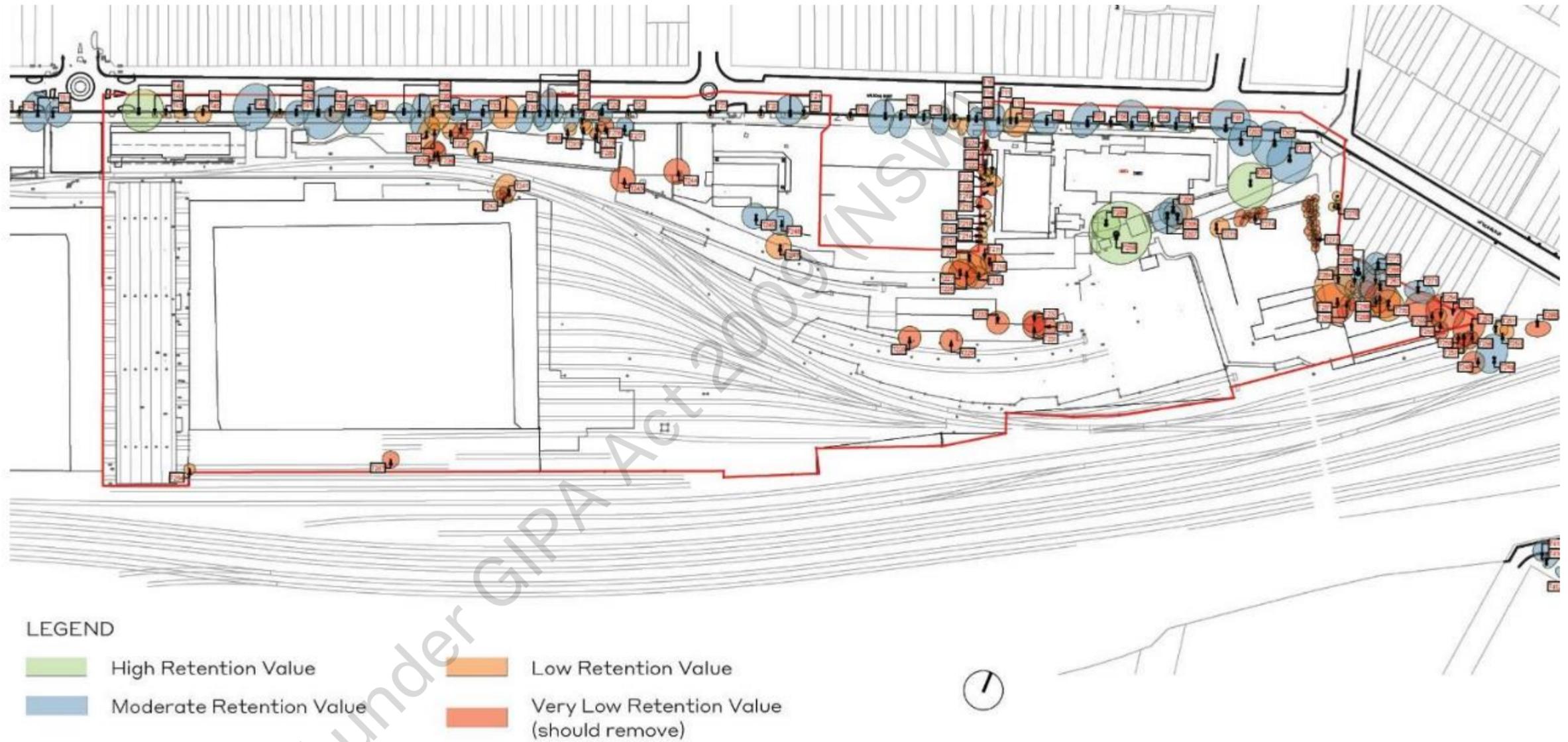
DPE, July 2022, Design Guidelines, Figure 2: Urban Strategy Map

Constraints Overview

Known Heritage Constraints

Environmental

Moderate retention value trees along Wilson Street



DRAFT Paint Shop Sub Precinct Design Guide (July 2022)
Figure 35: Significant Tree Retention

Constraints Overview

Known Environmental Constraints

Topography | Property

Landform – Elevation changes are substantial. Assuming 9m clearance and 0.7m bridge deck, then approximately:

- 10.8m rise/fall from north landing to ground
- 7m rise/fall from north landing to Wilson Street
- 14.6m rise/fall from south landing to ground

9m clearance to be challenged

Carriage Works

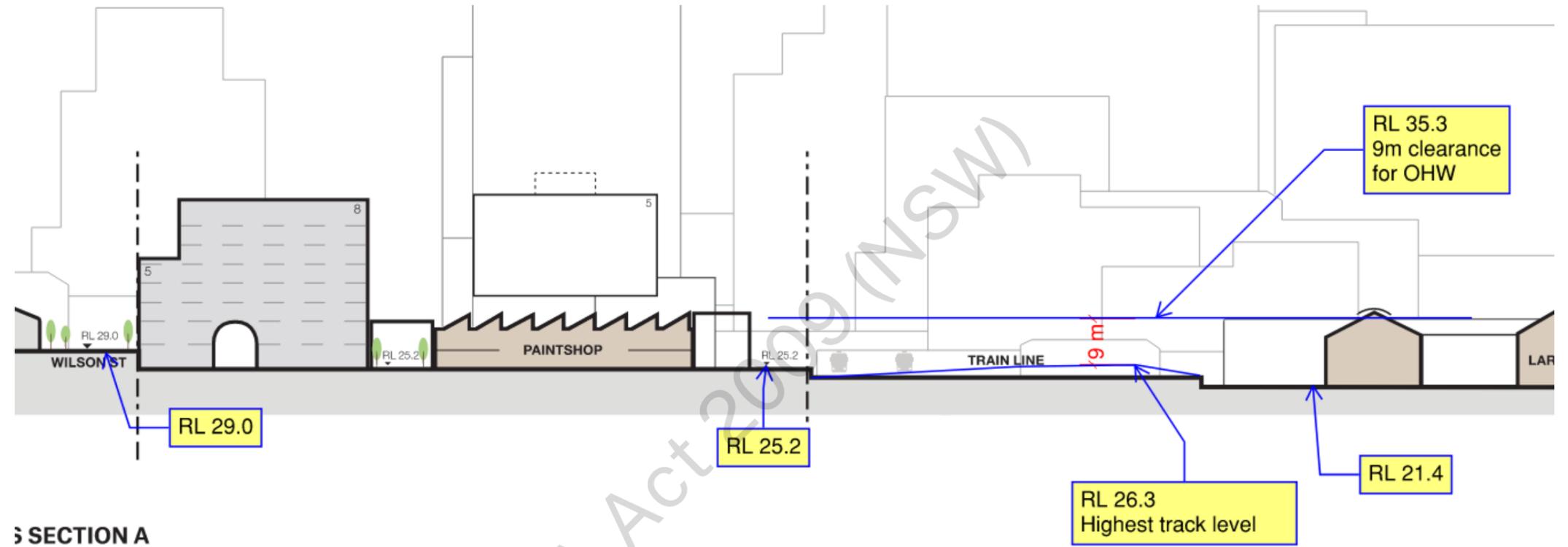
- Vehicle loading access along traverser

South Eveleigh landing zone

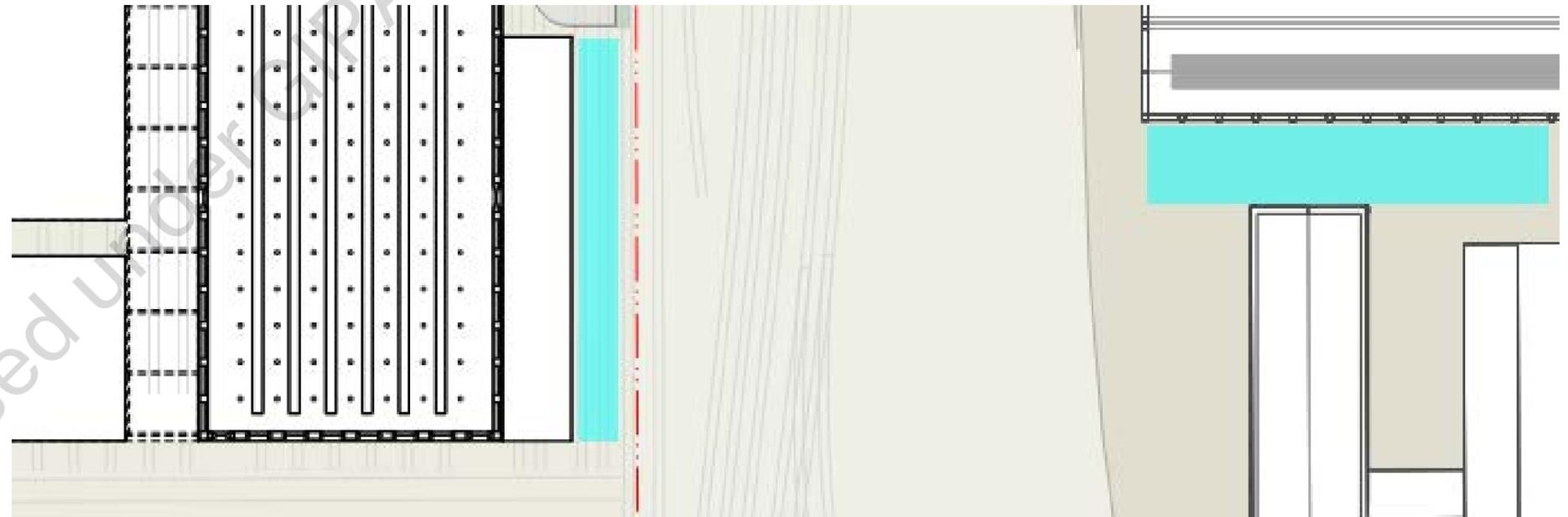
- Easement has been set aside, but the specific location is TBD. This is under an unsolicited proposal.

North Eveleigh landing zone

- Landing zone nominated as south of the paint shop. This may be amended. Traverser is to remain in-situ.



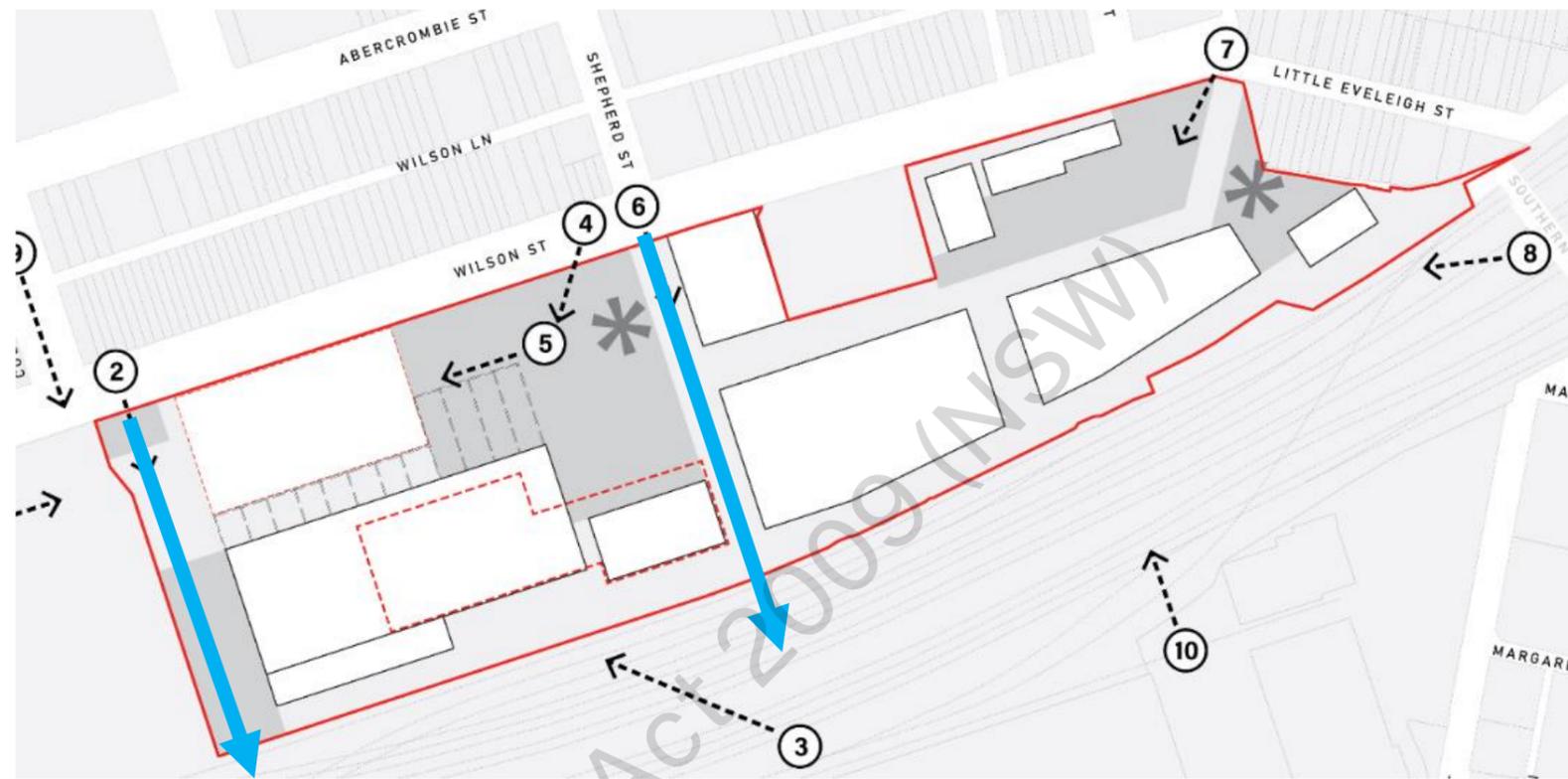
SECTION A



Constraints

Urban Planning

- Key sightlines from various entry points along Wilson St to south Eveleigh (Design Guidelines Figure 24, Key views map)
- Site saddles two catchments – Blackwattle Bay and Botany Bay
- Most north-south corridors are intended as activated frontages. Any impacts from piers would need to be carefully considered and/or used as an opportunity.
- Traverser planned for use as a creative space



DPE, July 2022, Design Guidelines Figure 24: Key Views Map and Figure 25: Active Frontages Map

Constraints

2022 Urban Planning

Constructability

Constructability was assessed in 2008 study based on the use of a 400-tonne crane.

- Proposed 400 tonne crane requires a 3 m width clearance for travel and access. The dimensions of the crane are 17.5 m long by 3.0 m wide, but it needs to stand on 4 outriggers at 10 m by 10 m.
- No launching or lifting a bridge over live rail line.
- Launching or lifting a bridge in night time rail possession is possible, acceptance is subject to a risk analysis
- Decks (precast concrete slabs or steel decks) cannot be installed over live rail lines - unless a catch deck was preinstalled.

Bridge construction options were investigated in 2017 study:

- Lifted by crane
- Launched with lateral slide
- Rotation of segments
- Segmental Construction

Constructability requires revisit due to current constraints.

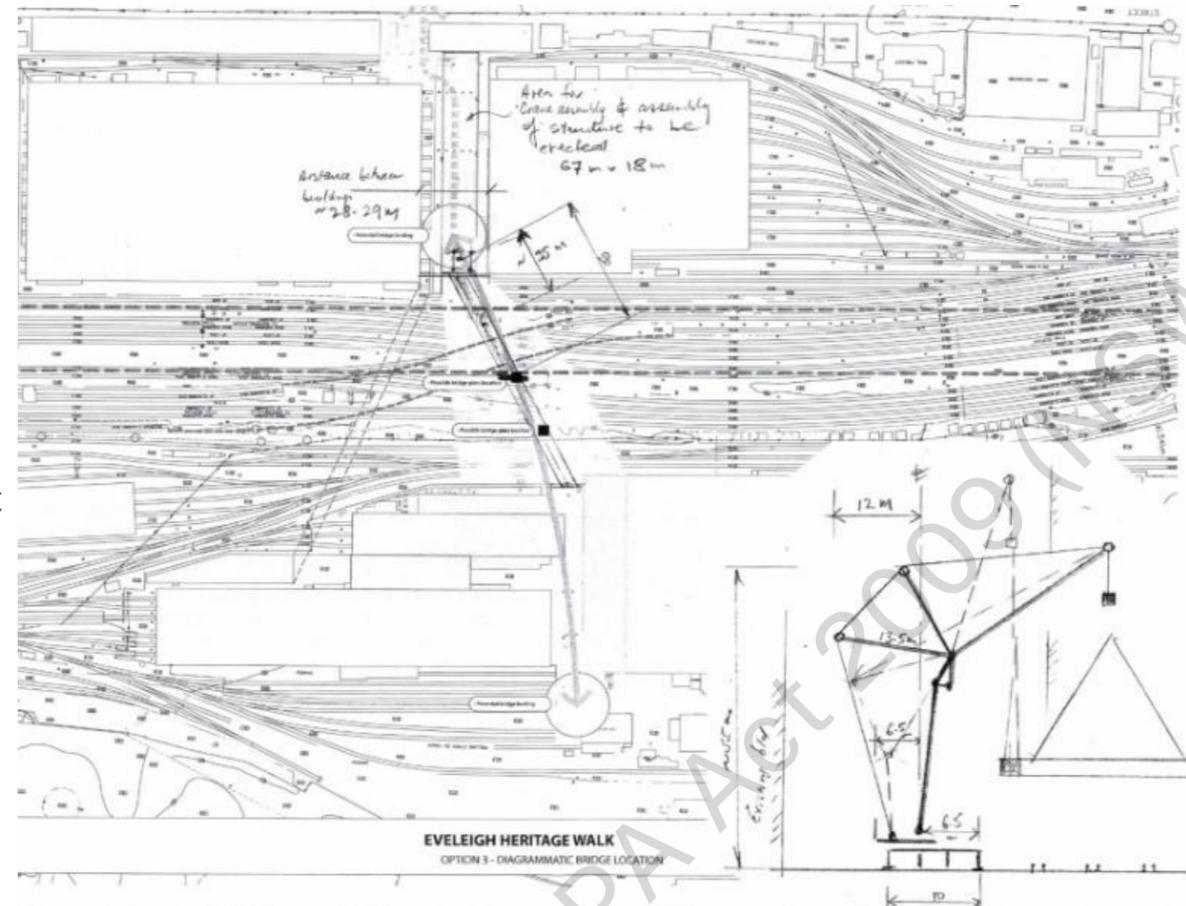
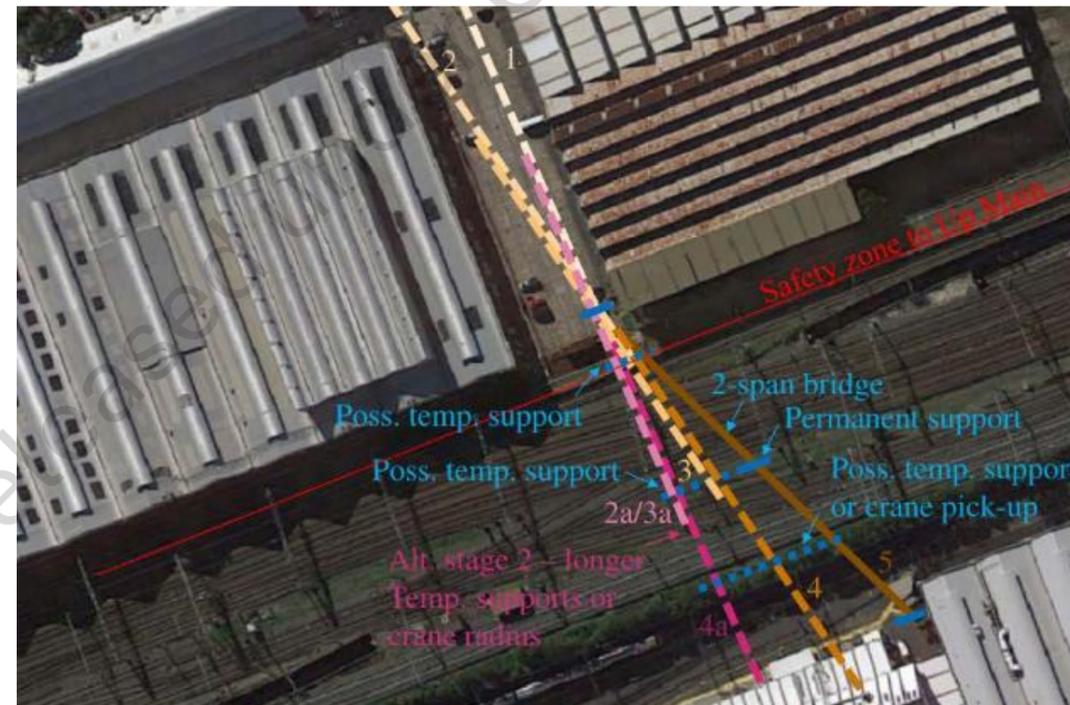
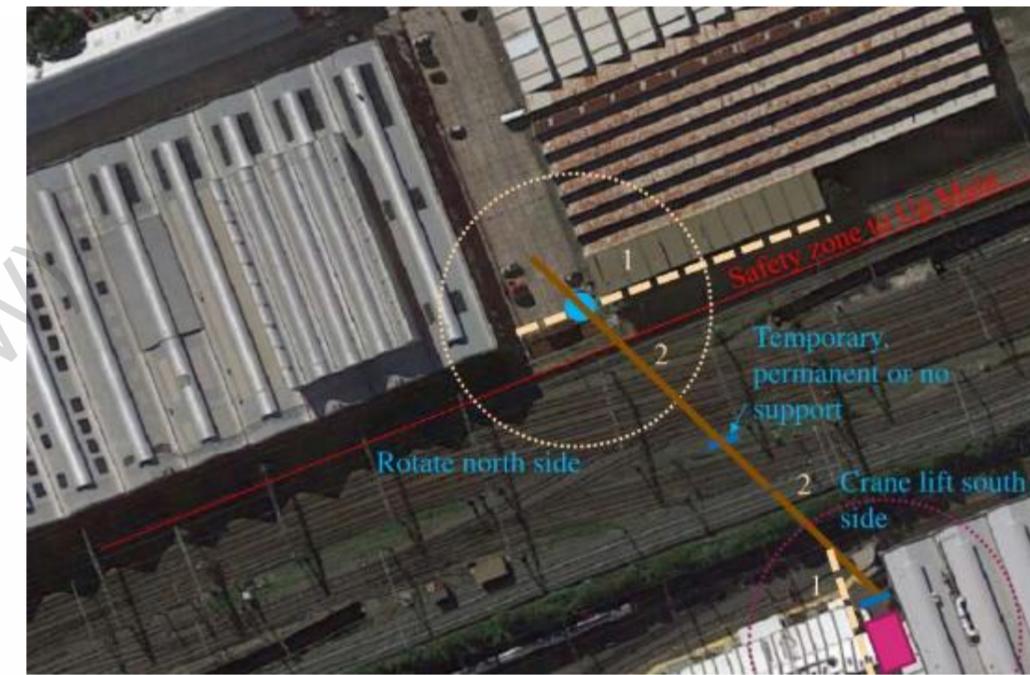


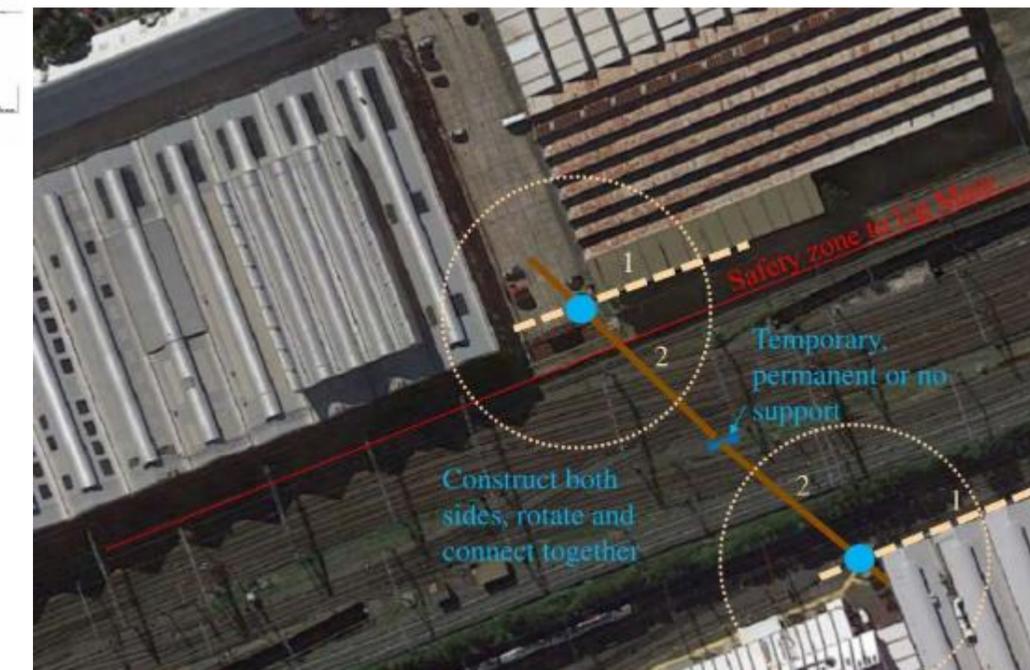
Diagram showing the 400-tonne crane placed on the traverser, Cox Sketch (2007)



Launched with lateral side



Rotation of first segment, crane lift of second segment



Rotation of both segments

Constraints

Constructability

Design requirements

Clearances

Deck Width

Grades

Protection Screens

Piers

Loading



Geometry | Clearances

AS5100 CL13.8

Vertical and horizontal clearances for bridges over rail shall be as required by the rail authority.

ESC215

Horizontal

Abutments 4300 from centerline of track

Piers 3500 from centerline of track

Footings 2150 from centerline of track

Vertical

6500 from low rail height

EP 08 00 00 01 S

For bridge > 8m in order to replacement OHW masts

Dimension	Structure
2 150mm	Minimum horizontal clearance to structures and structure footings to one metre below design rail level to allow for operation of ballast cleaners. No allowance is required for curve effects.
2 400mm	Signals and associated equipment to enable visibility of signals
3 000mm	OHWS masts and signal bridge masts adjacent to a track Temporary construction works adjacent to a track
3 500mm	Piers, columns, deflection walls between tracks
4 300mm	Bridge substructures and deflection walls (except between tracks) Cuttings without road access Station buildings Columns, footbridges OHWS masts and signal bridge masts on platforms Other structures located adjacent to non-electrified tracks and where road access is not required.
5 000mm	Other structures located adjacent to electrified tracks and where road access is not required
5 500mm	Other Structures and cuttings located adjacent to non-electrified tracks and where road access is required between the structure and the track (Note 1)
6 200mm	Other structures and cuttings located adjacent to electrified tracks and where road access is required between the structure and the track _(Note 1) Bridges or air-space developments where an overhead wiring or signal mast is required within the structure limits

ESC215 Table 1 – Mainline service requirements

For all track in **electrified** areas the minimum vertical dimension between the underside face of non-energised equipment and the design **maximum** height of the low rail shall be as detailed in Table 5.

Dimension	Overhead Wiring Configuration
5 900mm	Wiring Attached
6 500mm	Wiring Not Attached

Table 5 - Vertical clearance requirements to structures in electrified areas

ESC215

Minimum Clearance to Under-side of OLB – OHW Unattached.	<p>Both the bridge height and its width (along the track) influence whether OHW can pass unattached under a bridge (the preferred outcome), or whether the OHW needs to be attached (undesirable).</p> <p>As a guide, if the under-side of bridge is > 8m above track, then generally the OHW should be capable of being installed from standard OHW masts or portals, independent of the bridge, and therefore not attached to the bridge.</p> <p>For bridges lower than 8m, an OHW concept design is required to establish that the bridge height and width can allow the OHW to pass through unattached beneath the bridge, which is the preferred outcome (due to electrolysis corrosion considerations & ongoing maintenance). Alternatively, OHW may only be attached to the bridge if the OHW concept design can demonstrate that there are no other options because the bridge is too low and / or too wide (an undesirable outcome). In this case the concept design must identify how the OHW is to be supported & registered under the bridge, and how minimum electrical clearances are to be met.</p>
----------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

EP 08 00 00 01 SP

Design Requirements

Geometry | Clearances

Geometry | Deck Width

Minimum widths of Pedestrian Bridge (AS5100.1 CI 13.11)

Geometric requirements:

- Minimum 1.8m clear width between handrails
- Refer to Table 13.11

Cyclist and shared paths (AS5100.1 CI 13.13)

Geometric requirements:

- Refer Austroads Guide to Road Design, Part 6A
- **Disability Discrimination Act, and AS1428.1**

T HR CI 12030 ST

The width of footbridges shall be the greatest of the widths specified in AS 5100, the TfNSW stations and buildings standards specified in Section 9, and project and stakeholder requirements.

Geometry | Clearance Over

Pedestrian Bridge (AS5100.1 Table 13.7)

Geometric requirements:

- Vertical clearances *over* 2.4m

Cyclist and shared paths (AS5100.1 Table 13.7)

Geometric requirements:

- Vertical clearances *over* 2.7m



Released under GIPA Act 2009 (NSW)

Design Requirements

Geometry Grades

Pedestrian bridges (AS5100.1 Cl 13.11)

Table 13.11 requirements

TABLE 13.11
GEOMETRIC REQUIREMENTS
FOR PEDESTRIAN BRIDGES

Clear width between handrails	1.8 m min.
Ramp gradient	As specified by the relevant authority, but not steeper than 1 in 8
Stairway gradient	As specified by the relevant authority, but not steeper than 1 in 1.6

Cyclist and shared paths (AS5100.1 Cl 13.13)

Geometric requirements:

- Austroads Guide to Road Design, Part 6A
- **Disability Discrimination Act, and AS1428.1**



Design Requirements

Piers

AS5100.1 CI 15.3

Horizontal clear spans shall be provided, unless piers in corridor are approved by relevant authority.

If clearance to pier face:

- 0m to 10m, relevant authority approval is required.
- 10m to 20m, risk assessment to be undertaken

AS5100.1 CI 15.4.3

Pier thickness to be minimum 800mm

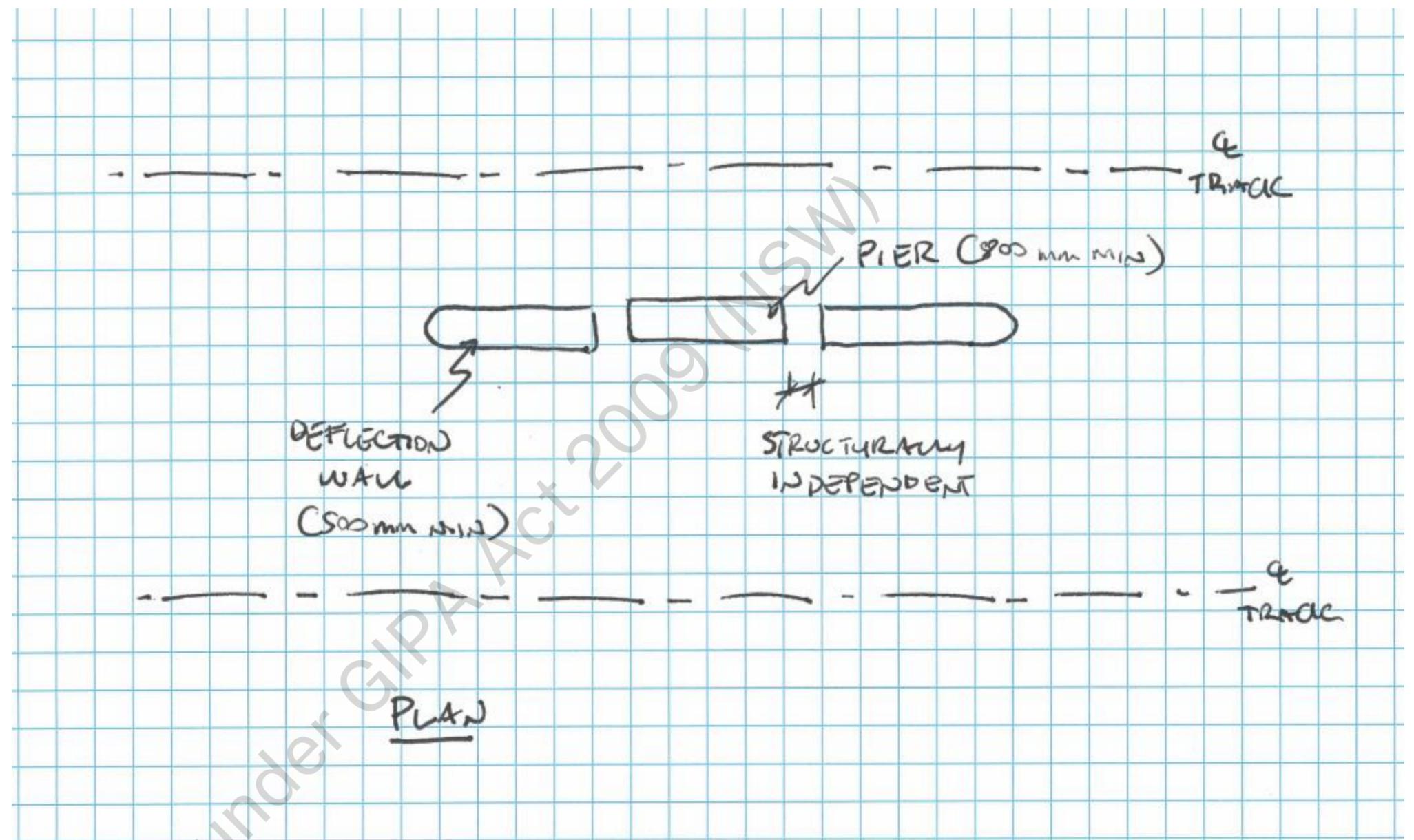
AS5100.1 CI 15.3.6

Deflection walls to be provided to protect pier
(introduced from 2017 revision of AS5100.1)

Deflection walls to be 500mm thick

T HR CI 12030 ST

- Footbridges shall comprise a clear span between abutments, except as permitted in this standard.
- Abutments that comply with the requirements of this standard and AS 5100 are permitted within the rail corridor.
- Footbridges without abutments shall comprise a clear span between outer piers.
- Intermediate piers are permissible when they are located on platforms that have the characteristics defined in Section 18.2.
- Frangible piers for footbridges shall not be used unless approved by the Lead Civil Engineer, ASA.



Sketch showing potential arrangement of piers



Design Requirements

Pier Design Requirements

Miscellaneous

T HR CI 12030 ST

Painting to be in accordance with SPC301. Colors shall not be red, orange or green. Paint shall not be intumescent

Surface drainage run-off water shall not discharge into the rail corridor.

T HR EL 10001 ST

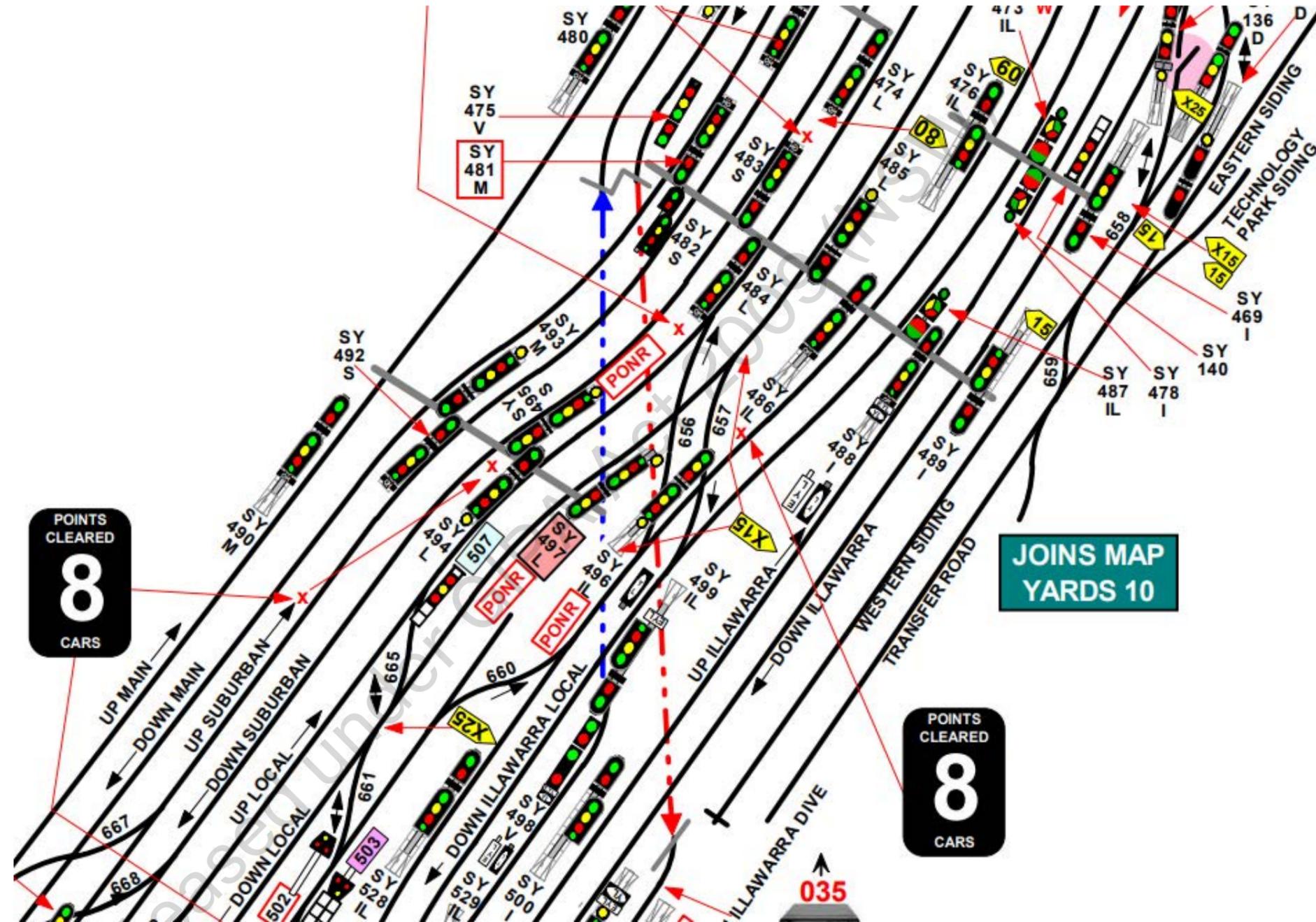
Clearances to HV electrical services

T HR CI 12030 ST

Earthing and bonding requirements

T HR SC 10001 ST

Signal sighting distances (6 seconds minimum)



Driver Route Knowledge Diagram indicating signal position

Design Requirements

Miscellaneous design requirements

Loading

Vertical Loading (AS5100.2 CI 11.4.3)

Between 0m to 5m

- loading 500kN

Between 5m to 10m

- loading 500kN to 0kN

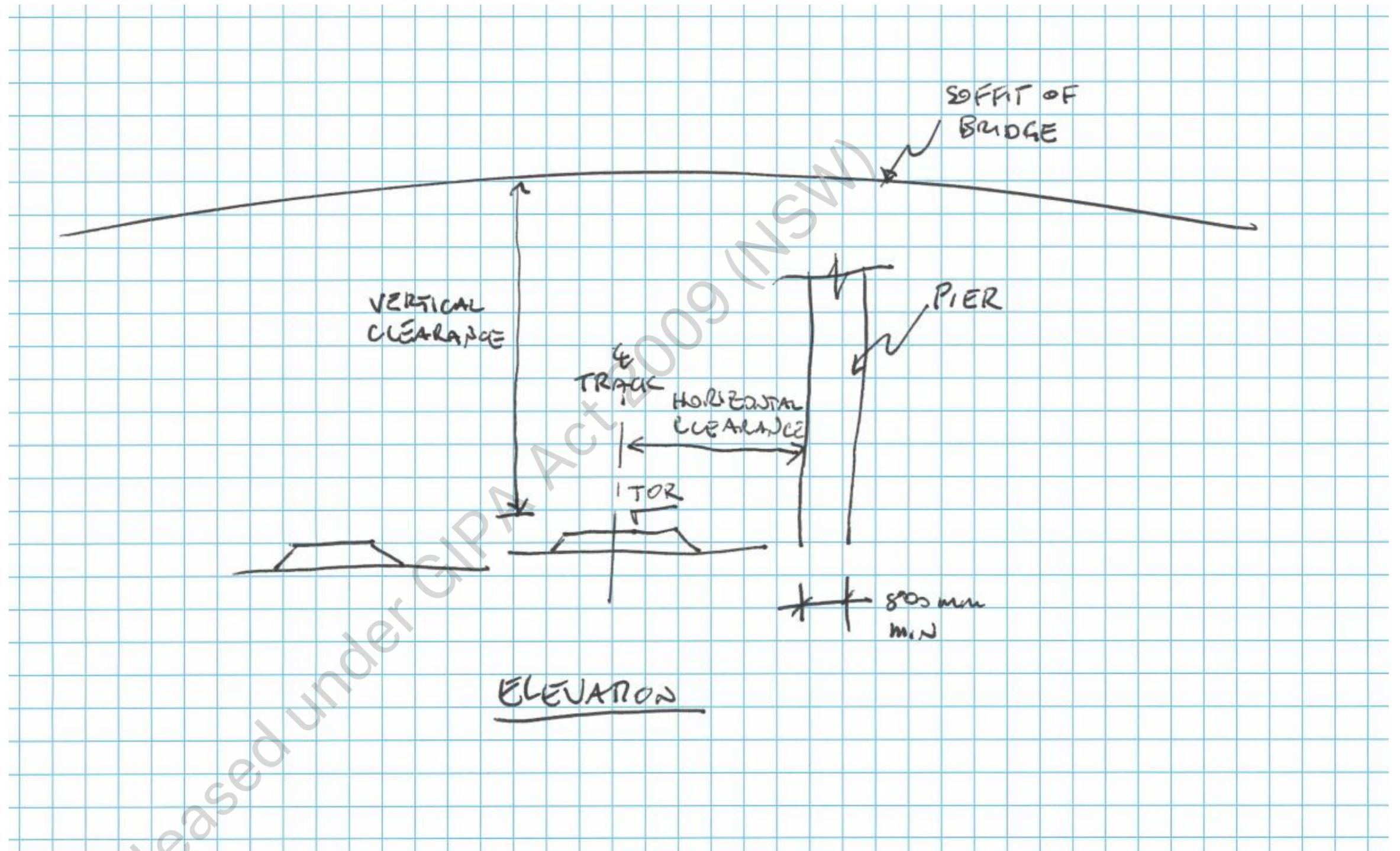
Horizontal Loading (AS5100.1 CI 15.3)

Between 0m to 10m loading

- 4000 kN parallel to rails.
- 1500 kN normal to rails.

10m to 20m loading

- 1500 kN



Sketch indicating clearances from rail

Design Requirements

Loading Requirements

Structural Forms

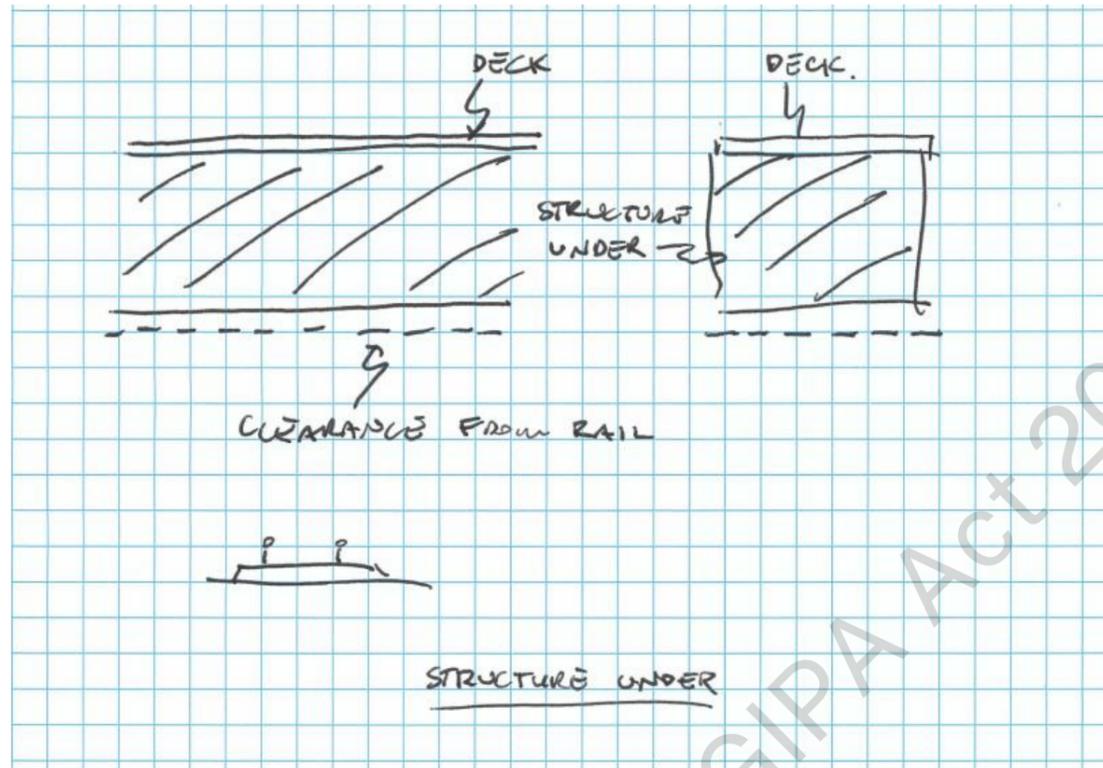
Superstructure Form

Substructure Form

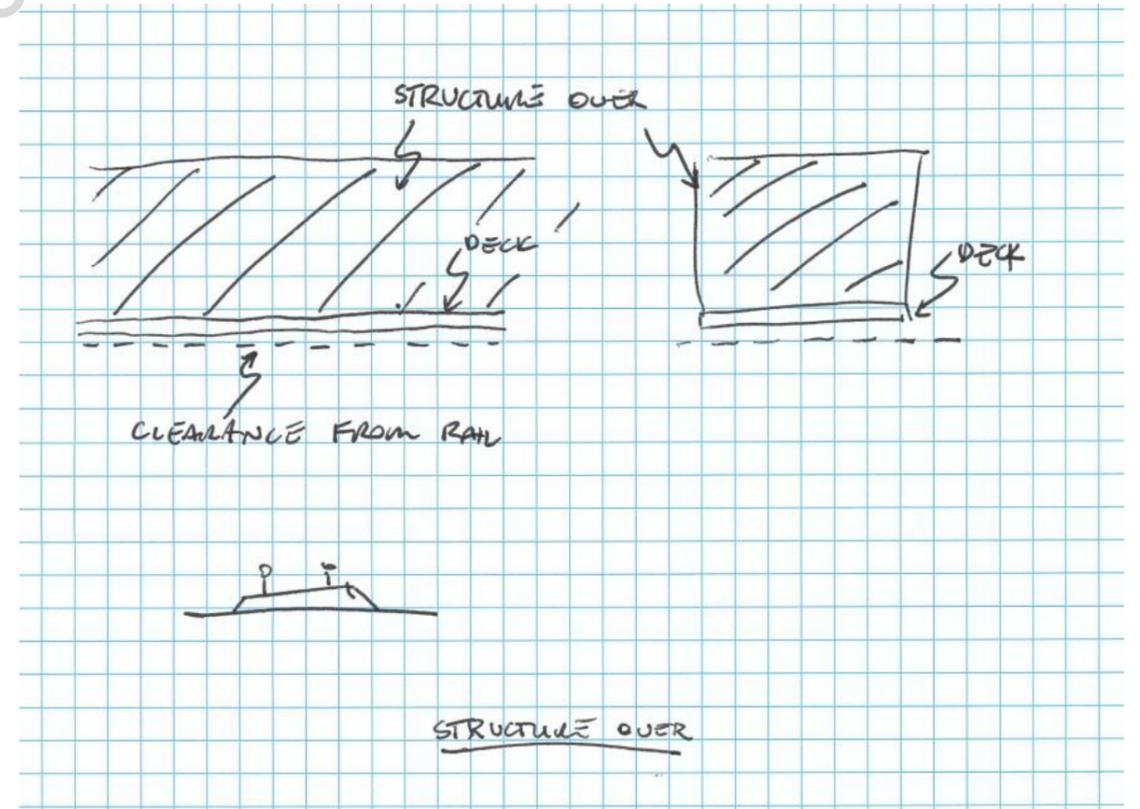


Superstructure Form

- “Structure over” or cable supported structures preferable to minimise deck elevation
- Steel work preferable to facilitate lifting
- Truss form and tied-arch likely to facilitate “structure over”
- Cable supported options (cable stayed or suspension bridge), which enable a slender deck and the ability to span across the rail corridor without an intermediate pier. Some potential challenges should also be addressed, such as planning approval for tall pylons, maintenance and whole of life.



Sketch showing “structure under deck”



Sketch showing “structure over deck”

Structural Forms

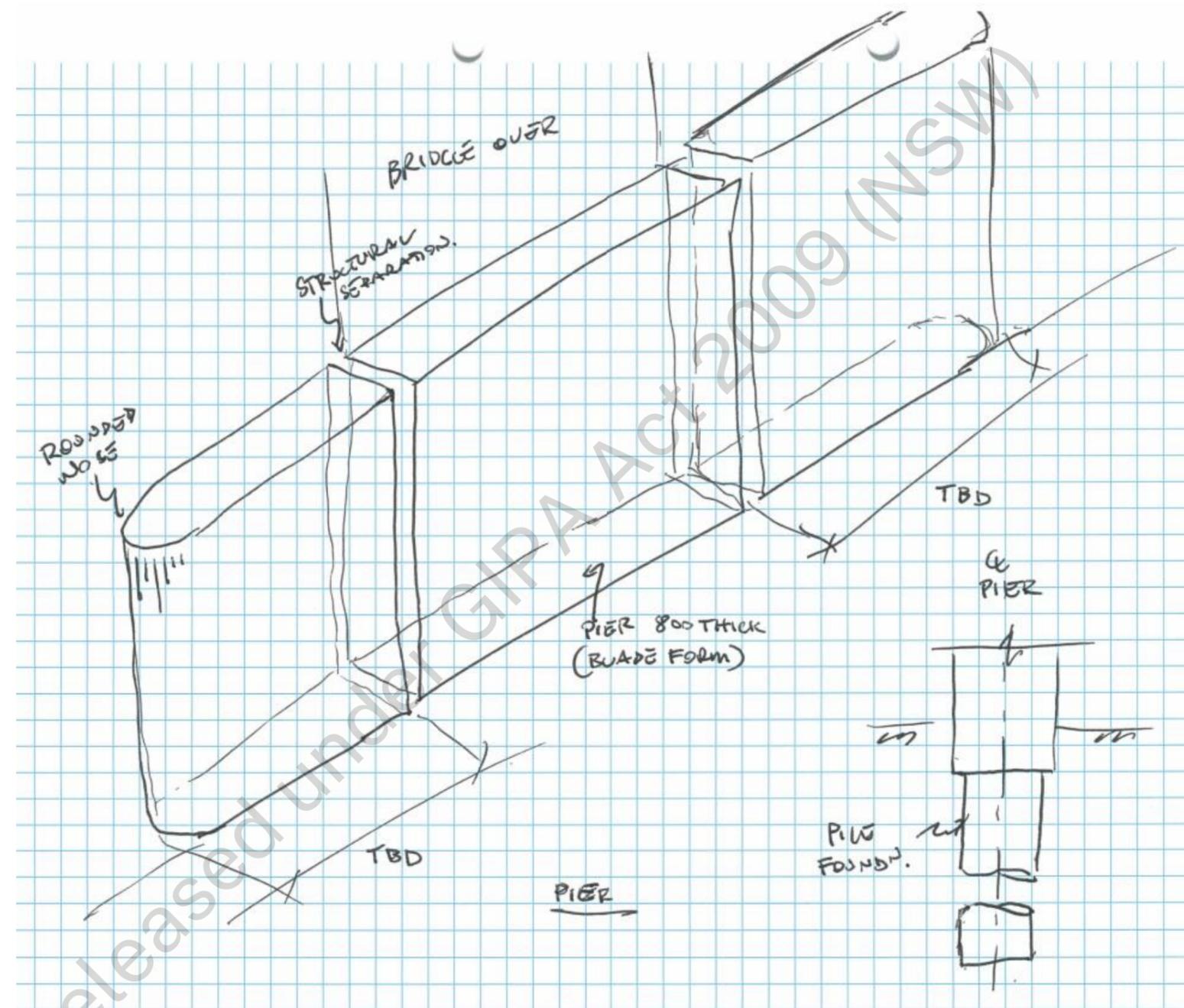
Substructure Form

Pier

- Blade form, 800mm thick
- Piled foundations
- Precast/Cast-in-situ TBD

Deflection walls

- “In front” of pier
- Structurally independent
- Rounded nose
- Length to TBD,
- Height presented may be optimized
- Precast/Cast-in-situ TBD
- Piled foundations



Sketch showing pier or pile foundation

Structural Forms

Substructure

Next Steps

Augmentation Options

Assumptions

Inputs

Risks

Opportunities

Further Design Development



Augmentation Options

Move Overhead Wiring

Move Signals

Attach Overhead to bridge

Change easement location

Bridge columns through the Paintshop to traverse over the Paintshop to Wilson street

Assumptions

Possession scheduling is assumed to be as per information nominated in 2017 report.

Given piers were shown in the 2017 report, we are currently assuming these can be placed in corridor – Relevant Authority approval is required (TfNSW/Sydney Trains)

Easement on south side is assumed to be available for landing (Mirvac easement)

Inputs

Bates Smart

- DDA access requirements including widths, stairs details and minimum / maximum grades.
- Connectivity
- Urban design treatment, pier shape, cladding, handrails
- Security requirements
- Lighting
- Lift size

Balarinji

- Connection with Country input

Curio

- Confirmation of heritage requirements / interface

Turf

- Landscape interface

Ethos Urban

- Property boundary constraints

Next Steps

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Risks

Approval from other asset owners and stakeholders

Constructability – safe access and space to build a bridge

Lack of information (survey, GI, rail possessions)

Coordination and integration of masterplan

Property boundaries

Opportunities

New alignment options – e.g. span over paintshop

Tunnelling

Further Design Development

SESA

Connectivity

Urban design

Whole of life

Wind and vibration design

Deck drainage

Constructability

Material

Maintenance consideration

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Next Steps



Yandhai Bridge, Nepean River



Lachlan's Line, North Ryde



Helix Bridge, Singapore



Kingsgate Footbridge, Durham



Sundial Bridge, California



Dafne Schippers Bridge, Utrecht

Inspiration

About Us

The analysis and report for this project was undertaken by Arup who have significant experience with analysing the design and performance of bridges and rail infrastructure.

References + Standards

To complete the analysis and reporting, a series of standards and documents were reviewed and considered as part of the process.

The following standards were used as references:

- AS5100-2017 - Bridge Design
- BTD 2012/01 - Provision of Safety Screens on Bridges
- ESC215 – Transit Space
- EP 08 00 00 01 S - Overhead Wiring Standards for the Electrification of New Routes
- T HR CI 12030 ST - Overbridges and Footbridges
- T HR EL 10001 ST - HV Aerial Line Standards for Design and Construction
- T HR SC 10001 ST – Signalling Design Principle

Documents from the following projects were referred to:

- Eveleigh Heritage Walk *for Redfern Waterloo Authority* [2008 study]
- Carriageworks to Australian Technology Park – North-South Pedestrian Link *for Urban Growth* [2017 study]

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Redfern North Eveleigh Bridge

Transport for New South Wales

Feasibility Study & Concept Options Report

Rev 1

25 November 2022



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 4. Bridge design – Piers and spans
 5. Bridge design – Landing zones
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 4. Access
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 6. South Landing Zone
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 8. Stairs and Lifts
 9. Other Design Considerations
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Objectives of the Study

Arup has been commissioned to investigate the feasibility of a bridge that connects RNE to South Eveleigh and enables pedestrian and cyclist patronage by considering constraints, design requirements, bridge constructability, risks, opportunities and future design development.

A conceptual sketch produced as part of this feasibility study was used to inform a high level cost estimate.

Executive Summary

The Redfern North Eveleigh bridge will be a very challenging, expensive bridge to build and does not provide outstanding time savings or convenience for users.

The evaluation of possible alignments for the bridge and possible time savings are addressed in the following slides.

Further, due to the elevation of the site, and the significant interface with train operations, there will be substantial cost required to build the bridge

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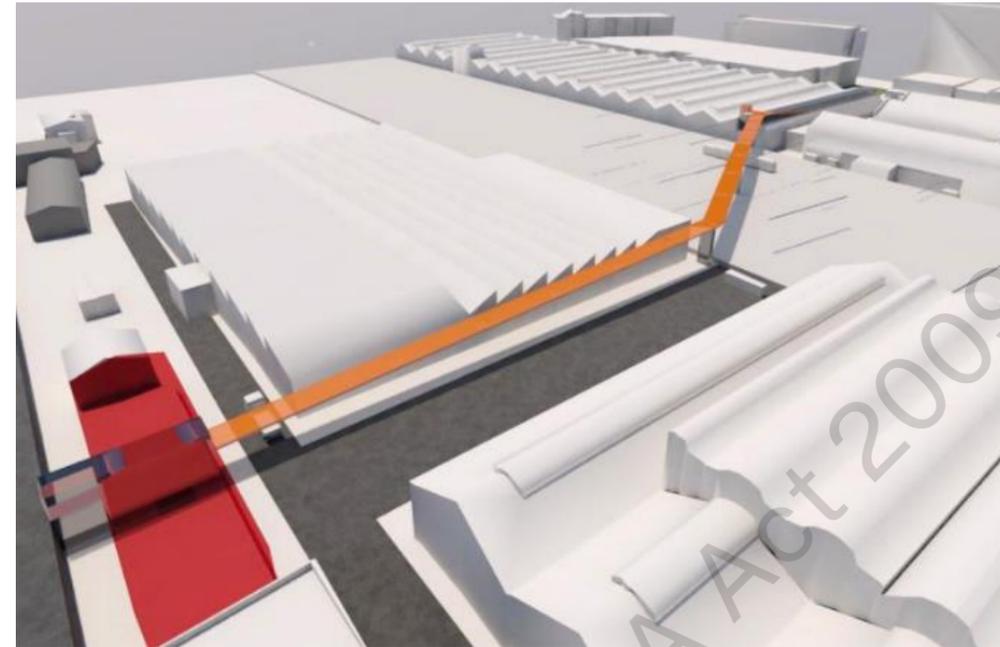


Previous Studies

Arup was previously commissioned in 2008 and 2017 to review the site constraints including constructability, and to develop sketches of bridge concepts for preliminary costing.

During the early studies, sites to the east were favoured over the western alignments because the bridge length could be minimized. In addition the siting provided space for a pier approximately at its midspan when considering the constraints of available space in the rail corridor. As the 2008 study was undertaken prior to the installation of the new Redfern Station crossing, ‘duplication’ of an existing alignment was not a reason to discount these options at the time. The second platform access bridge at Redfern Station is currently under construction and due for completion in Q1 2023.

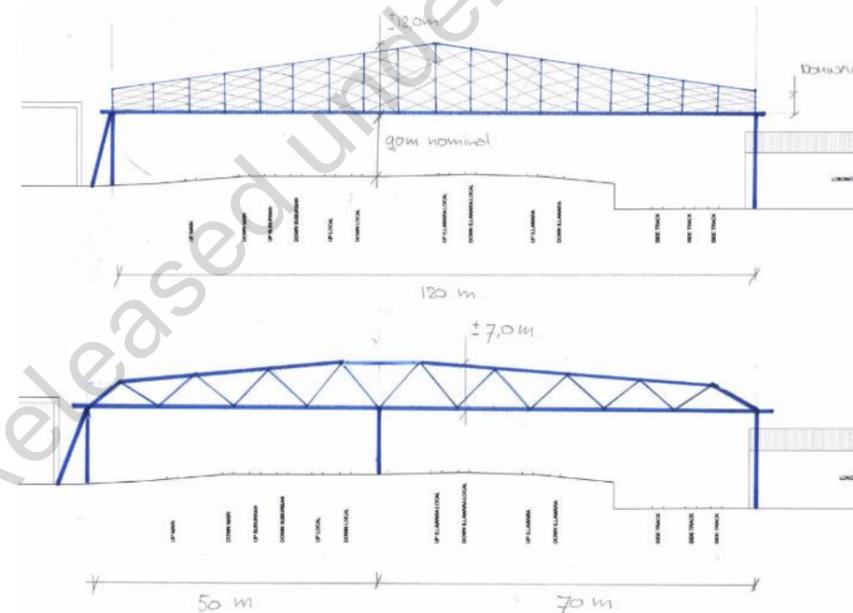
Early studies also featured a ramped landing direct from the bridge to Wilson Street. The previous design brief included the requirement for DDA ramps (grade 1 in 20). Due to the topology and level differences, it was more efficient to extend the ramp directly to Wilson Steet instead of ramping down to the traverser, then ramping back up to street level.



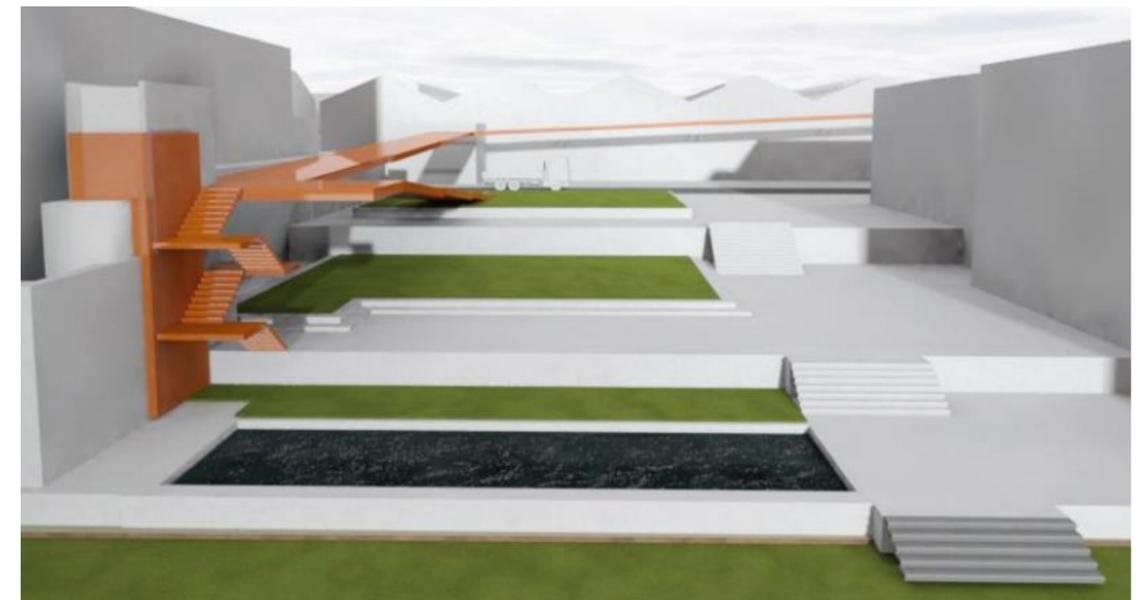
North landing to Wilson Street



South landing option in Locomotive Shed bay



Truss options with pier, clear spans are ~50-120m



South landing option along village square (Between Channel 7 and CBA)

What characteristics should a bridge have?

The RNE bridge should be a connection across the impenetrable rail corridor, saving time, encouraging permeability, and generally be a convenient, safe and accessible piece of infrastructure.

	Connect the North and South Eveleigh communities		Accessible
	Provide local permeability across the rail corridor		Sustainable
	Safe		Sympathetic to the industrial heritage of the area
	Comfortable		Connection to Country
	Convenient		Value for Money
	Provide time savings for pedestrians and cyclists		

Potential Time Savings

This section explores the potential connectivity benefits of a bridge.

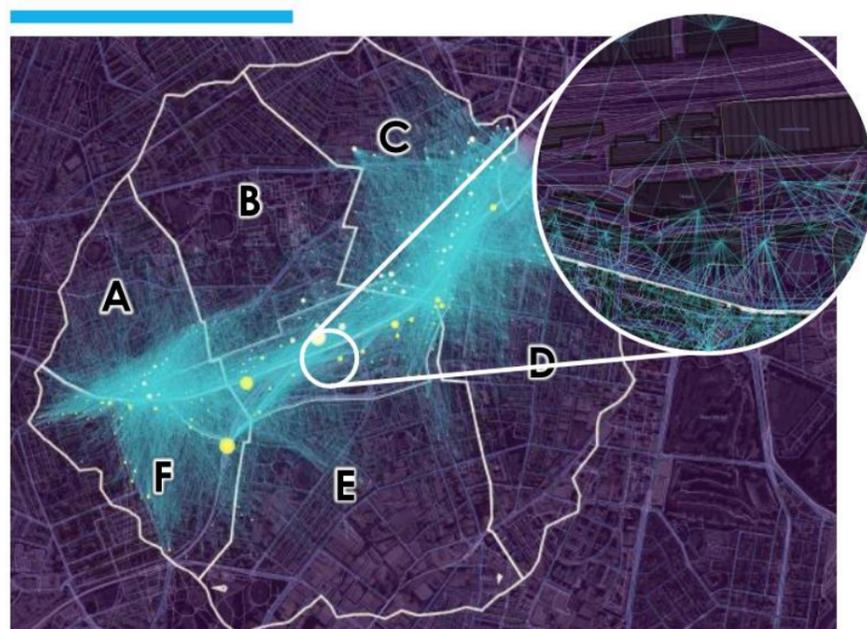


Current and Future Demand

From Bridge Catchment Analysis, SCT Consulting, 2021

Current demand

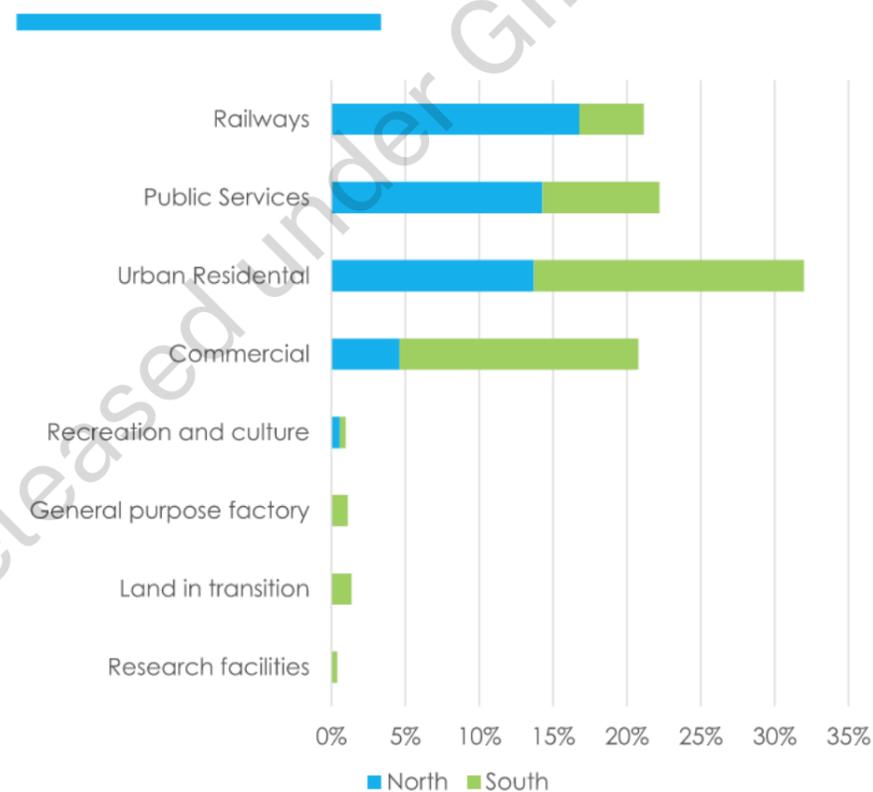
340-420 journeys per weekday, 53% are less than 1000m in length.



Cross-corridor trips by land-use

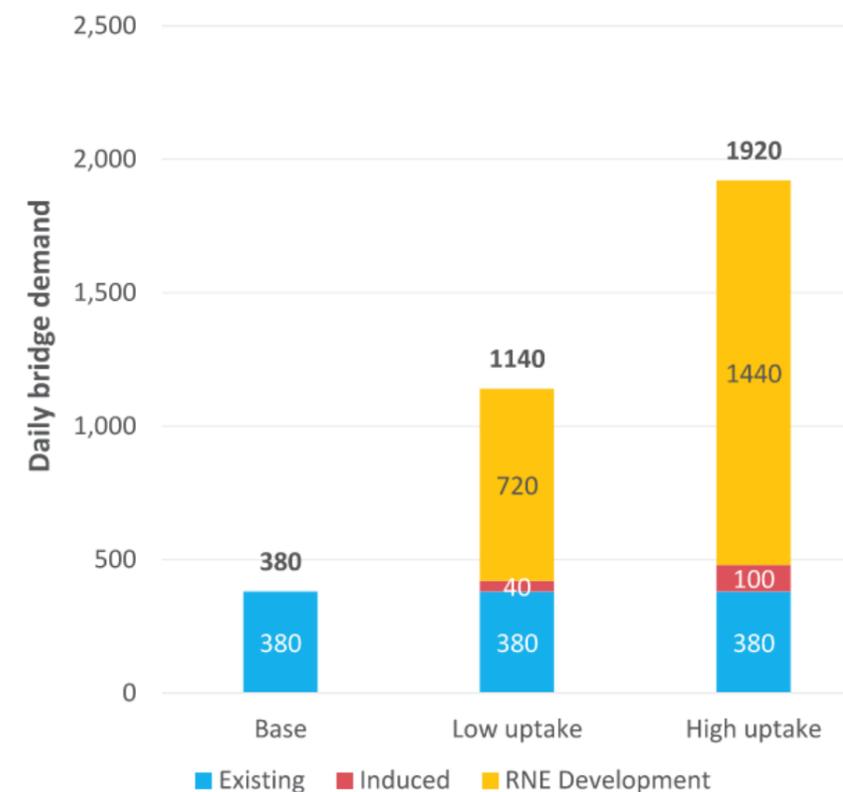
Main beneficiaries of the additional bridge are cross-rail corridor journeys to/from:

- Urban residential
- Public services (University of Sydney)
- Commercial (North and South Eveleigh precincts).
- Light industrial and commercial (Waterloo and Green Square)



Future demand

1140 – 1920 crossings per day



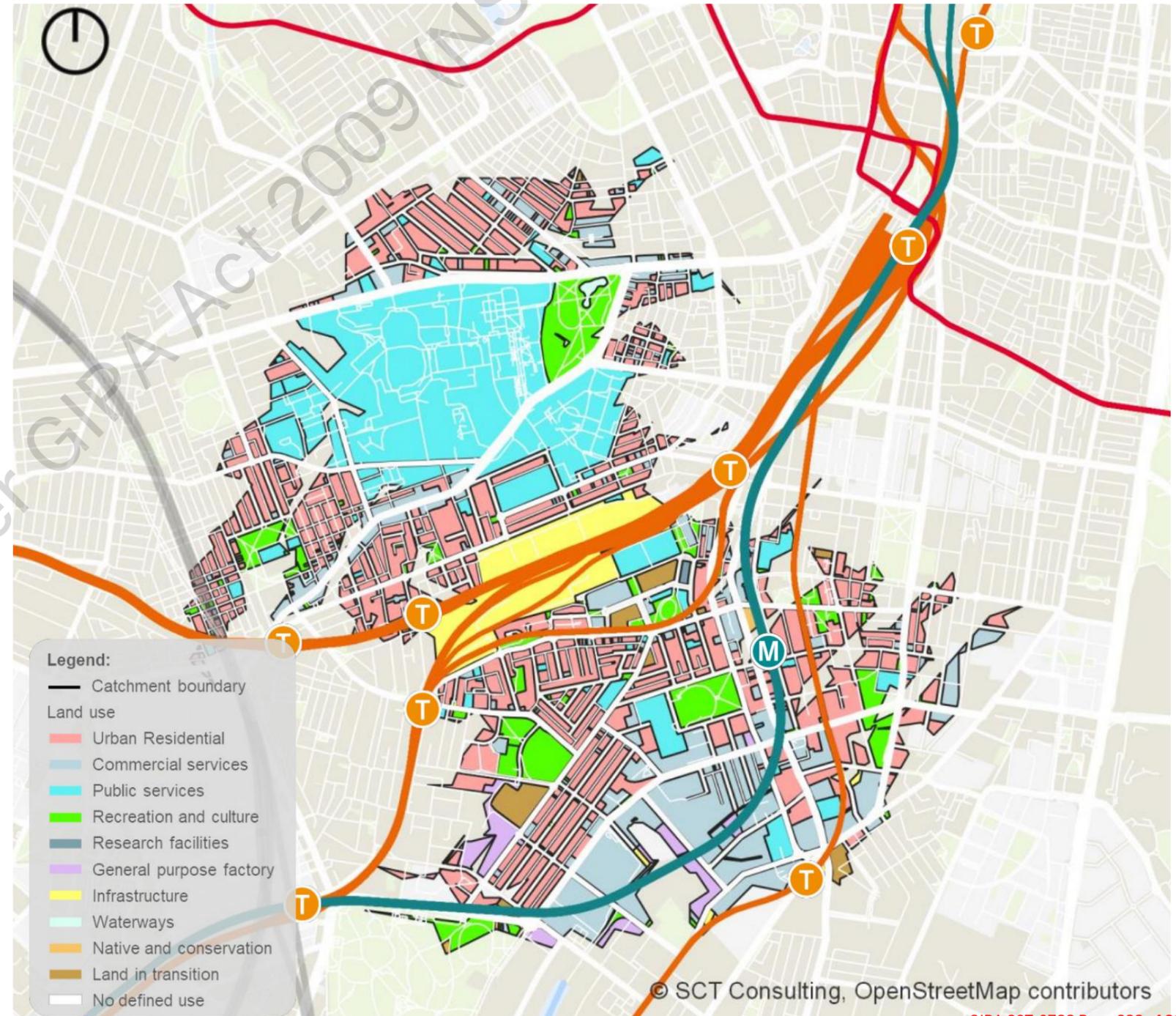
Expected patronage is **1140-1920 people per day**, which is very small. In comparison George street between Albert Street and Philip Street (Redfern) sees about 2000 journeys per day, during both weekdays and the weekend.

Travel Time Savings

From Bridge Catchment Analysis, SCT Consulting, 2021

SCT Consulting (021) estimated the average travel time savings as 5-8 minutes for cross corridor journeys in the highlighted regions. However, as you need to climb up the stairs or take the elevator up to cross over the rail lines, this is reduced to an **overall estimated time saving of 3–6 minutes per trip.**

Savings also become less pronounced for origins and destinations further away from the bridge.



Example pedestrian journey from ABS to Waterloo Metro Station

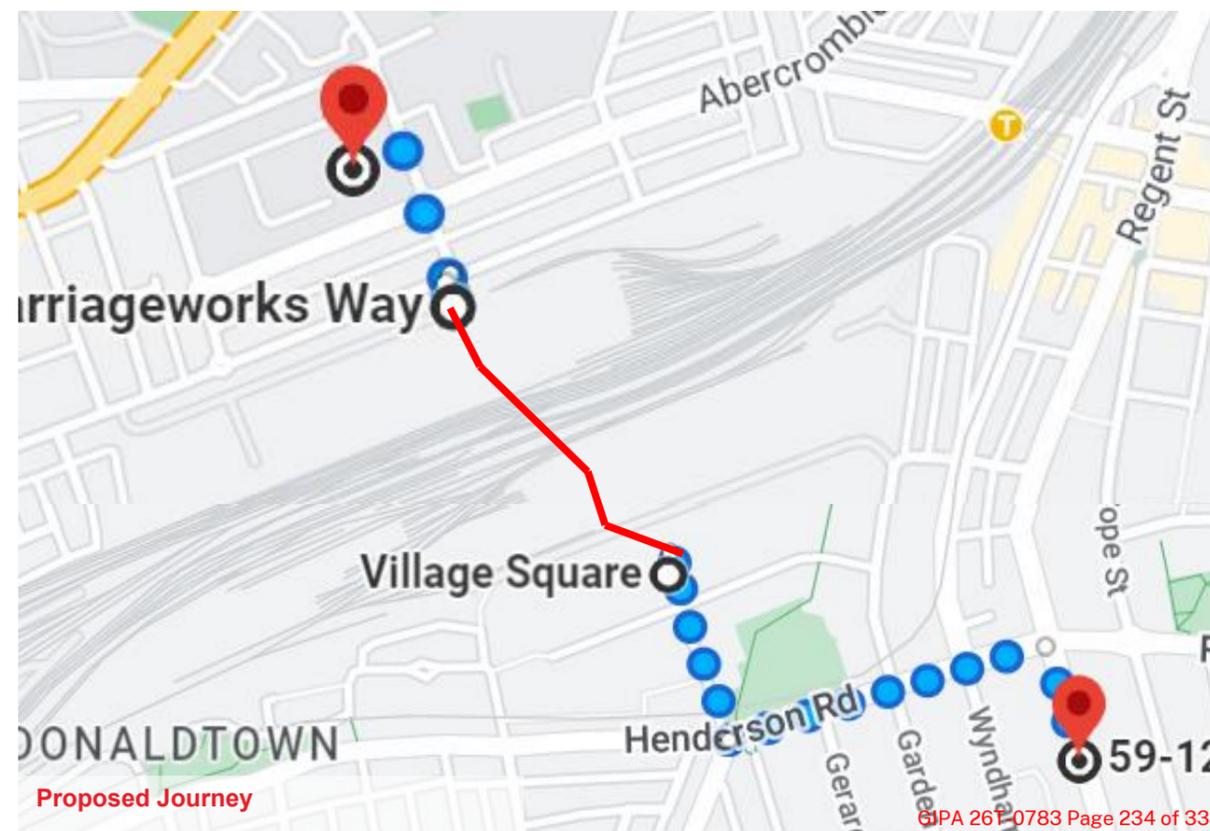
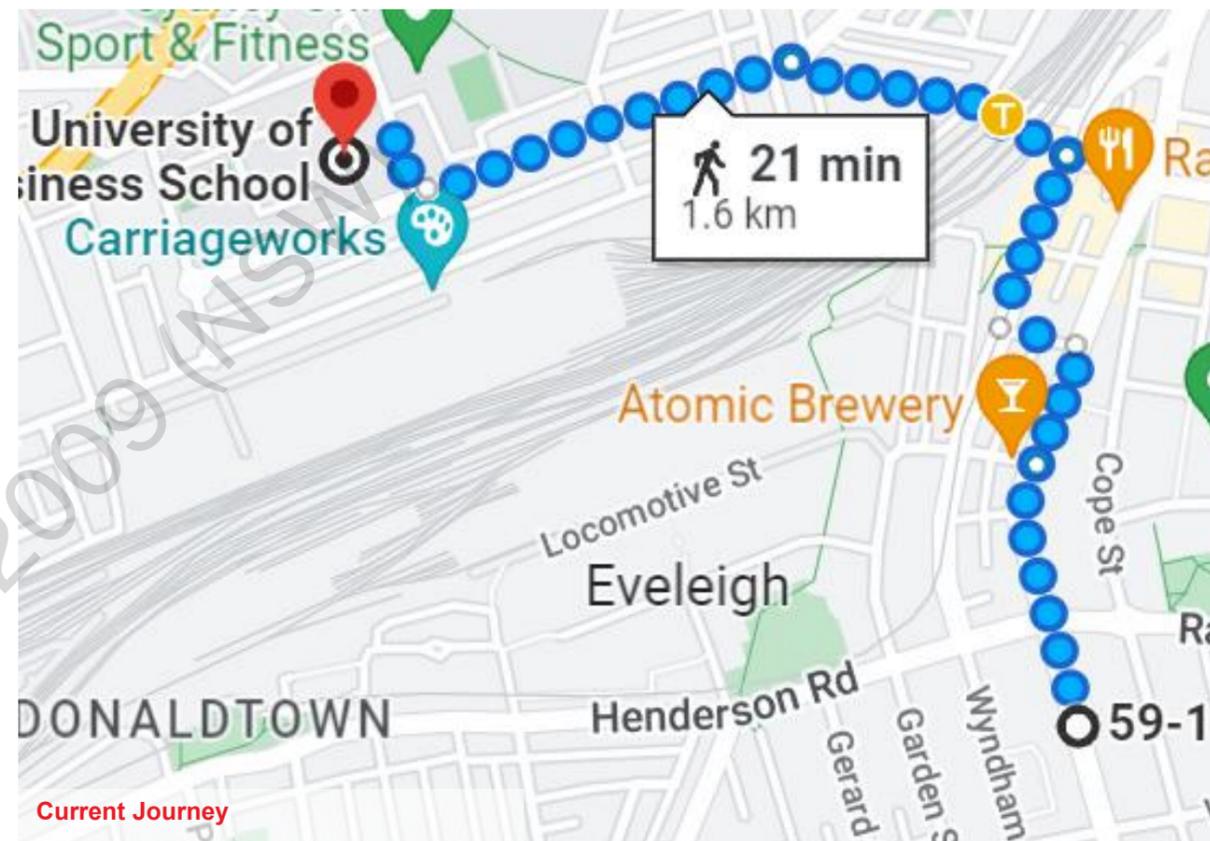
From University of Sydney Abercrombie Business School (ABS)
To Waterloo Metro Station

Current journey time: 21 min

Proposed journey time: 17 min

- ABS to Carriageworks 3 min
- Carriageworks to Village Green via bridge 3 min
- Stairs/Lifts at each end 2 min
- Village Green to Waterloo Station 9 min

Approximate time saving: 4 min



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Bridge Siting Commentary

Alignments for bridge sites are explored under different design considerations.

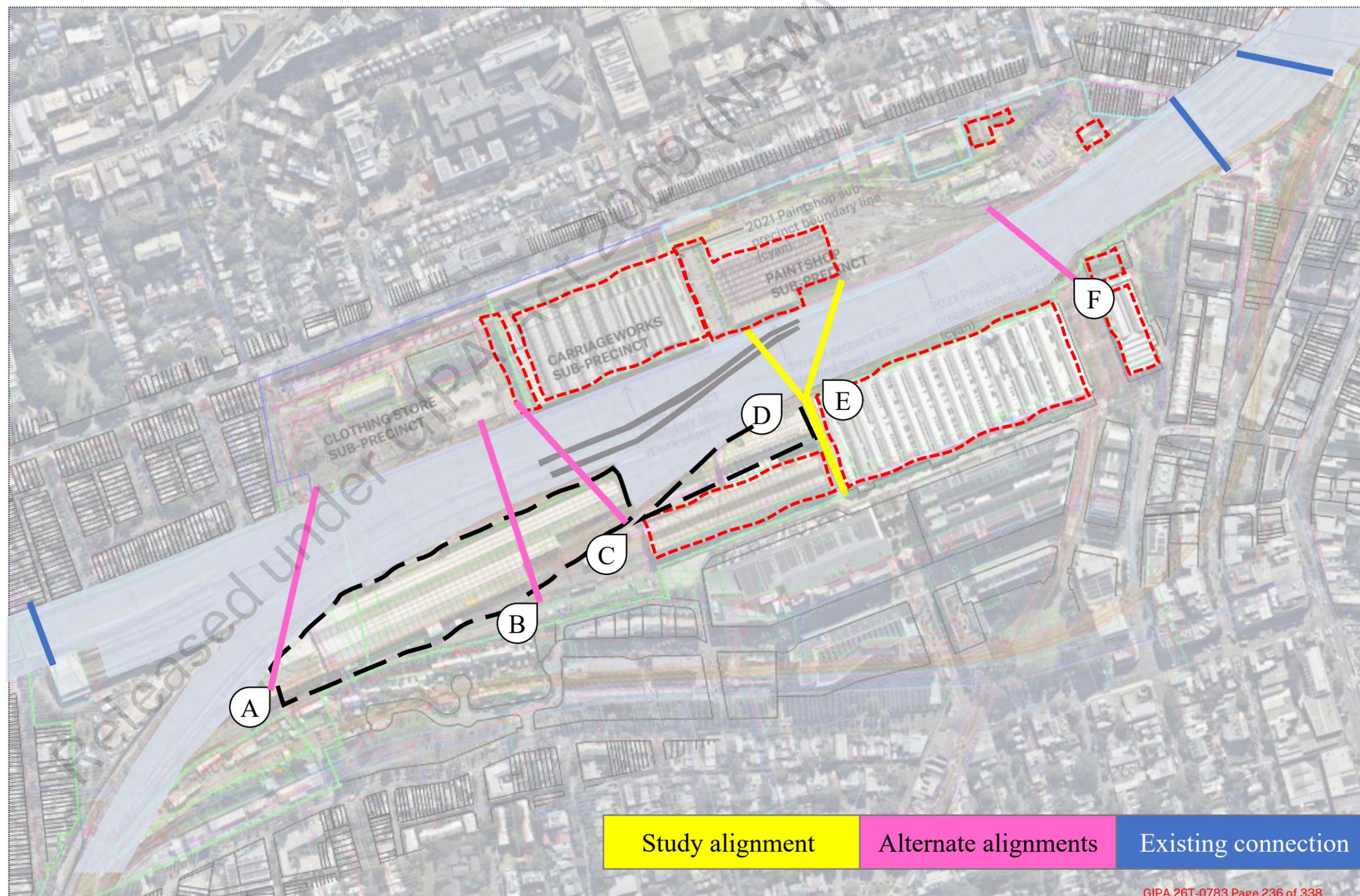
This section selects two of the alignments to be considered further.



Bridge Siting Commentary – Challenges associated with the options

-  Minimum 10m clearance height above rail corridor; HV cable, drainage at rail corridor
-  Illawarra Dive (tunnel)
-  Eveleigh Maintenance Centre
-  Heritage

- A: Minor benefit to permeability
- B: No immediately obvious space for piers and deflection walls. Needs to extend over Maintenance facility.
- C: Limited space to position pier in rail corridor
- D: Work in proximity to heritage listed assets
- E: Work in proximity to heritage listed assets and new development
- F: Too close to the second pedestrian crossing at Redfern Station. Minimal additional benefit to permeability.



Description of Options

Six alignment options are listed and compared in different parameters.

	A	B	C	D	E	F
Alignment	East of Clothing Store Precinct to east end of Eveleigh	Connection from Clothing Store Precinct perpendicular to the tracks	West corner of Carriageworks to west of Large Erecting Shed (LES).	West corner of Paint Shop to west of Locomotive Shed (the Loco).	East corner of Paint Shop to west of the Loco.	Far east end of the Redfern North Eveleigh (RNE) development to Innovation Plaza.
Assumptions	Eveleigh Maintenance Centre is operational.	Depends on approval to span over the operational Eveleigh Maintenance Centre.	Eveleigh Maintenance Centre is operational.			
			Easement for landing needs to be provided by Sydney Trains.	Easement for the south landing can be secured within the access corridor for the current Eveleigh Rail Workshops.	Easement for the south landing can be secured within the access corridor for the current Eveleigh Rail Workshops.	Easement will be secured for the north and south landings.

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Connections to the RNE development

The bridge should provide connectivity from the proposed development at the North Eveleigh Site to surrounding areas of interest.

	A	B	C	D	E	F
Connectivity	Low connectivity	Low-moderate connectivity	Moderate connectivity	Moderate-high connectivity	Moderate-high connectivity	Low connectivity
Comments	Flow to Erskineville town centre, primarily residential connection	May connect to the Australian Technology Precinct (ATP)	Connection to ATP	Connection to ATP	Connection to ATP. Path of travel visible from Fan of Tracks.	Landing located closer to the development, but minimal additional benefit compared to the new Redfern concourse.
Distance*	~1000m, 10-15 min walk from east of paint shop to south landing	~700m, 5-10 min walk from east of paint shop to south landing	~700m, ~10 min walk from east of paint shop to south landing	~300m, ~5 min walk from east of paint shop to south landing	~200m, ~5 min walk from east of paint shop to south landing	~300m, ~5 min walk from east of paint shop to south landing

* Assuming 10 min per km walking speed and 3 minutes to get up and down from the deck to ground.

Local Connections - Permeability across the rail corridor

The bridge should better connect North and South Eveleigh.

Proximity to existing crossings diminish the permeability benefit.

	A	B	C	D	E	F
Comments	Minor increase to permeability	Nil or undetermined increase to permeability	Moderate increase to permeability	High increase to permeability	Moderate to high increase to permeability	Minor increase to permeability
Nearest existing crossing	300m west at Burren Street	500m west at Burren Street	600m west at Burren Street	600m east at Redfern station	500m east at Redfern station	150m east at Redfern station
	Primarily residential to residential. No benefit to South / North RNE developments	Minimal benefit if Maintenance Centre remains. Local benefits depends on future development of the Maintenance Centre.	Connection to ATP, Carriageworks and to Sydney University. May facilitate connection to Waterloo.	Near linear connection from University of Sydney Business School, Codrington St, Carriageworks, and to ATP. May facilitate connection to Waterloo.	Connection from University of Sydney via Shepherd St, RNE precinct, and to ATP. May facilitate connection to Waterloo.	Too close to the second pedestrian crossing at Redfern Station.

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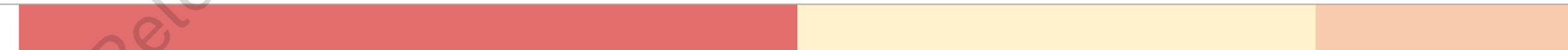


Bridge Design – Piers and Spans

Too long a clear span increases the size of the structure and complexity of construction.

	A	B	C	D	E	F
Piers	Potential location for two piers in the rail corridor.	Very congested tracks. No immediately obvious space for piers and deflection walls.	Very congested tracks. One potential candidate location for pier.	Potential location for one pier in the rail corridor.	Potential location for one pier in the rail corridor.	Potential location, but in tight space, for one pier in the rail corridor.
Clear span	Assumed clear span of 50m.	Need to span the full 100m in a clear span and 100m span over the facility	Assumed clear span of 80 or 150m.	Assumed clear span of 50m.	Assumed clear span of 60m.	Assumed clear span of 50m.
Minimum length	250m	200m	150m	100m + 50m walkway	120m + 50m walkway	130m
Likely Superstructure	Truss	Cable stayed	Cable stayed	Truss	Truss	Truss

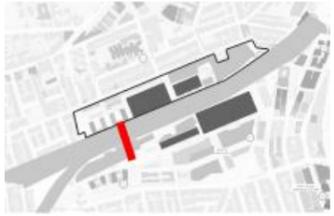
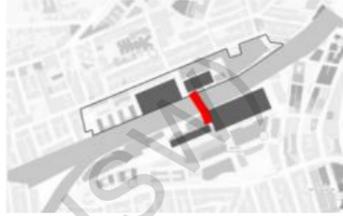
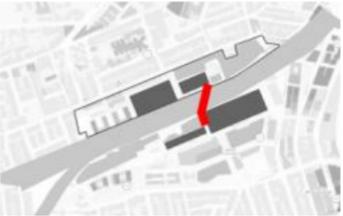
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Bridge Design – Landing Zones

Landing zone are where the bridges touch the ground to the north and south of the rail corridor.

Existing users, heritage, masterplan, and other constraints will restrict suitability of the landing zones.

	A	B	C	D	E	F
North landing						
	May need to land adjacent to, or span over, what appears to be a traction substation.	Suitable landing areas contingent on changes to maintenance facility.	Minimal space south of Carriageworks. Piers will need to be located at the end of the Traverser. Heritage impact may unacceptable.	Grassed area behind paint shop annex.	Grassed area behind paint shop. Spatial coordination required with Block K.	Assume area can be accommodated in RNE development.
South landing	Approval required from Sydney Trains to utilise maintenance facility for landing.	Approval required from Sydney trains to span over maintenance facility.	Landing at accessway to maintenance sheds. approval required from Sydney Trains.	Assumption easement has been set-aside for the landing as part of the unsolicited proposal. Approval required from Sydney trains to land in maintenance facility access.	Assumption easement has been set-aside for the landing as part of the unsolicited proposal. Approval required from Sydney trains to land in maintenance facility access.	Possible landing zone area north of the Innovation Plaza, but adjacent to maintenance dive. Impact on main pedestrian entry from Redfern Station to South Eveleigh.

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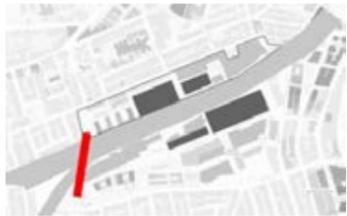
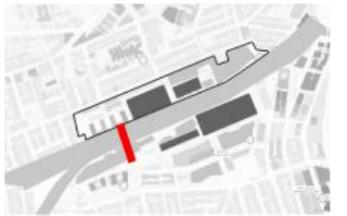
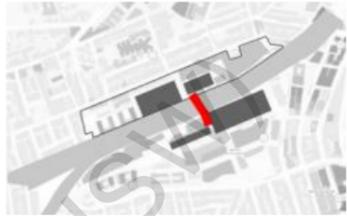
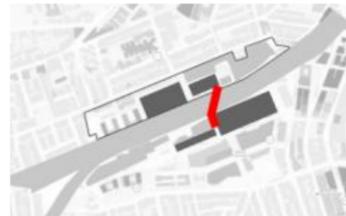
Stakeholder Impacts

The site of the bridge is a live rail corridor, very close to central station and a critical artery for the train network. Any design will require close cooperation with Sydney Trains; from the pier in the rail corridor to abutments in the operations and maintenance facility.

There will be additional design requirements on the structure because of the rail corridor (e.g. deflection walls in case of train collision).

All designs will need to be approved by Sydney Trains.

Certain alignments may also impact local residents.

	A	B	C	D	E	F
Sydney Trains	 <p>Need approval to construct piers in rail corridor.</p> <p>Need approval to land abutment in maintenance facility and access areas</p>	 <p>Need approval to span over maintenance facility.</p> <p>Need approval to land abutment and access in maintenance facility circulation area.</p>	 <p>Need approval to construct piers in rail corridor.</p> <p>Need approval to span over maintenance facility.</p>	 <p>Need approval to construct piers in rail corridor.</p> <p>Need approval to land abutment and access in maintenance facility circulation area.</p>	 <p>Need approval to construct piers in rail corridor.</p> <p>Need approval to land abutment and access in maintenance facility circulation area.</p>	 <p>Need approval to construct piers in rail corridor.</p> <p>Need approval to land abutment adjacent to maintenance dive</p>
Local Residents						
ATP	No direct connection	No direct connection	No direct connection	Connectivity	Connectivity	Minimal increase to connectivity.

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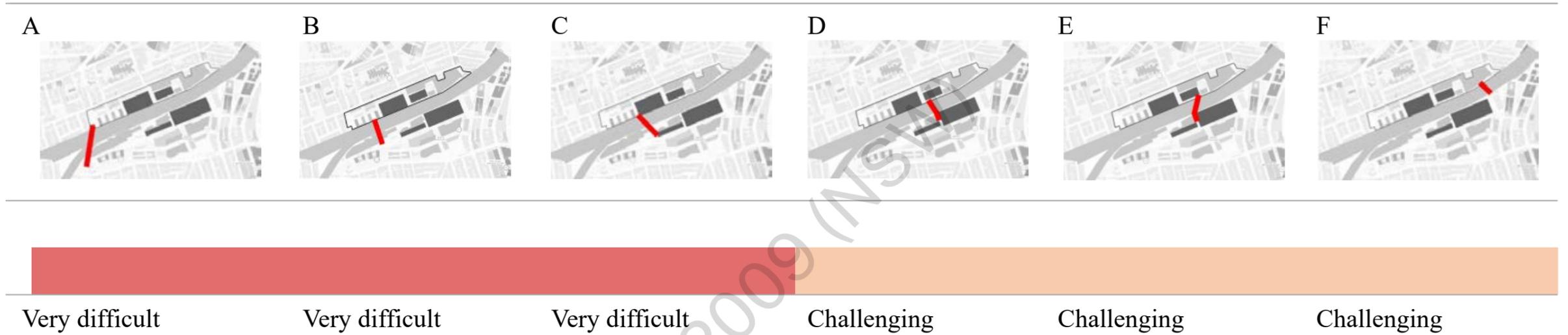
Constructability

Construction in the rail corridor is very challenging, expensive, risky, and will take several years.

Piling, pile caps, pier and deflection wall works will need to be constructed during possessions. That is in circumstances where constraints permit construction of structural supports

The bridge will likely be launched or lifted in segments. This too will need to occur during possessions as lifting or launching over a live rail line is not permitted.

As an optimistic assumption, there may be up to two 36- or 48-hour possessions per year, and this would indicate a construction duration of 3.5 years for the D & E options.



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High Level Summary

	A	B	C	D	E	F	
Connections to RNE							Connections near the Paint Shop precinct and/or Carriageworks are more central to the proposed development.
Local Permeability	Orange		Yellow		Green		Alignments adjacent to the Paint Shop suit desired lines to USyd, ATP, and potentially to Waterloo. New crossings too close to existing crossings provide less opportunity for enhanced permeability.
Bridge Design – Piers and spans	Red			Yellow		Orange	Longer spans increase complexity. Minimum span for any option is ~50m. Piers in the rail corridor and maintenance areas requires Sydney Trains approval.
Bridge Design – Landing Zones	Orange	Red		Orange			Existing users, heritage, masterplan, and other constraints restrict suitability of landing zones.
Stakeholder Impacts	Orange						The bridge must seek Sydney Trains engagement and approval. Some alignments may impact local residents (e.g. shading).
Constructability	Red			Orange			Construction in the rail corridor is possession dependent. Design and construction is expensive, risky, and will take several years to build (minimum 3.5-4 years) for a pier in a single config.

Considered further Considered further

Bridge Form Options

This section does not present the final forms of the bridge.

The models shown are the 3D equivalent of 'back of envelope' sketches to inform high level design, construction and cost estimation.

This report does not seek to define the urban design outcomes for the area. It only considers how the engineering design may interact with the masterplan, feasibility and site constraints.



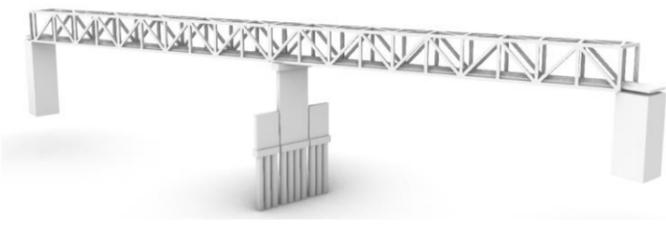
Superstructure - General Forms

The images presented are generic bridge forms to suggest the typologies of possible bridges.

Throughout the iterative design process, the design principles for the site would be integrated with structurally feasible solutions.

It should be noted that all bridge forms must satisfy minimum clearance of 10m above railway track to avoid clashing with the existing OHW and signal gantries.

A **truss form** was identified as the least obtrusive form and was taken forward for the purpose of this study. Weathering steel could be used for the construction, which would also eliminate maintenance requirements for painting.

	Truss	Tied Arch	Cable-Stayed
			
Height of spanning structure	5 – 6.5m tall	10 – 15m tall (from tying chord to highest point at arch)	Pylon height ~25 – 30m
Span length	50 – 65m	50 – 65m	100 – 130m
Other requirements	Central pier required	Central pier required	Need space for the back stay (image shown is a comparatively compact arrangement) Needs very tall pylons of ~ 25-30m high
	<div style="background-color: #fff9c4; height: 20px; width: 100%;"></div> <div style="background-color: #ffcc99; height: 20px; width: 100%;"></div>		
	<p>Considered further Form is sympathetic to industrial character of the surrounds.</p>		

Pier in the Rail Corridor

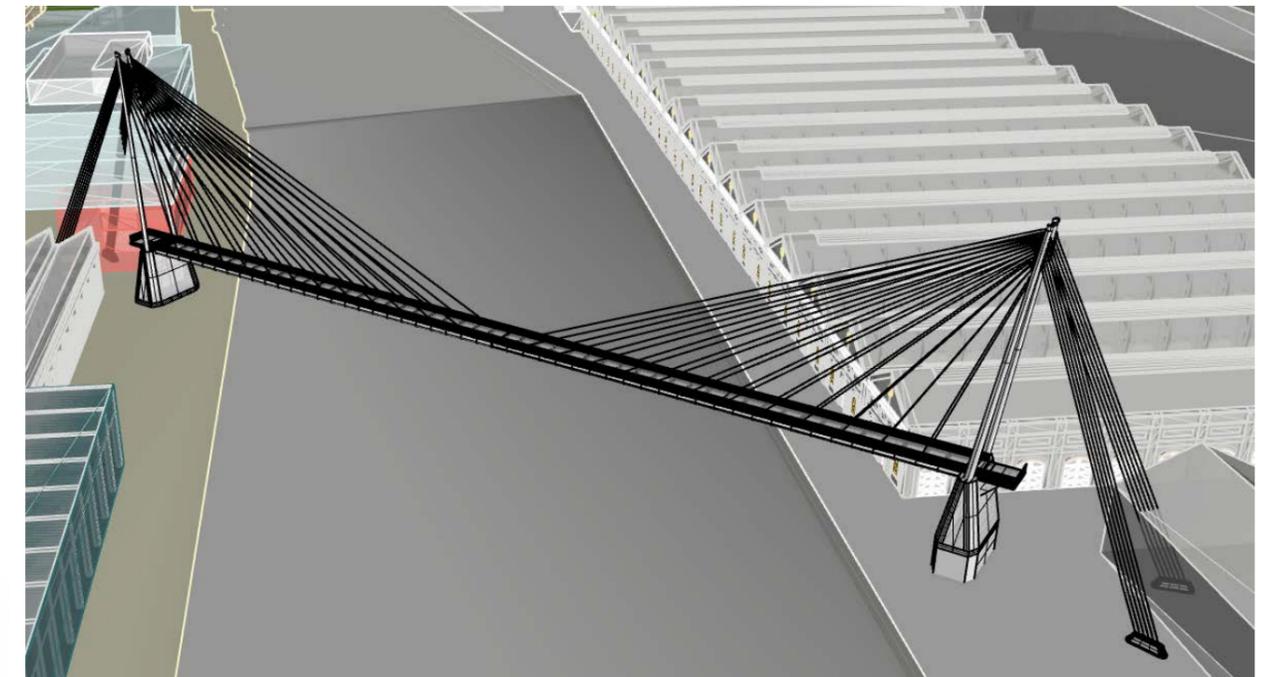
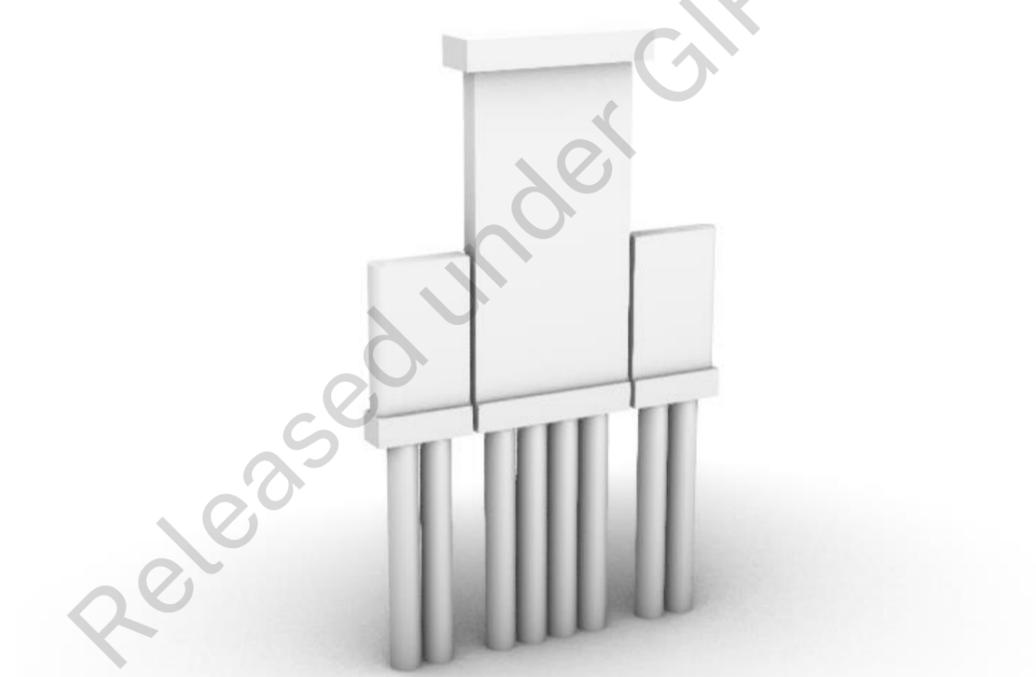
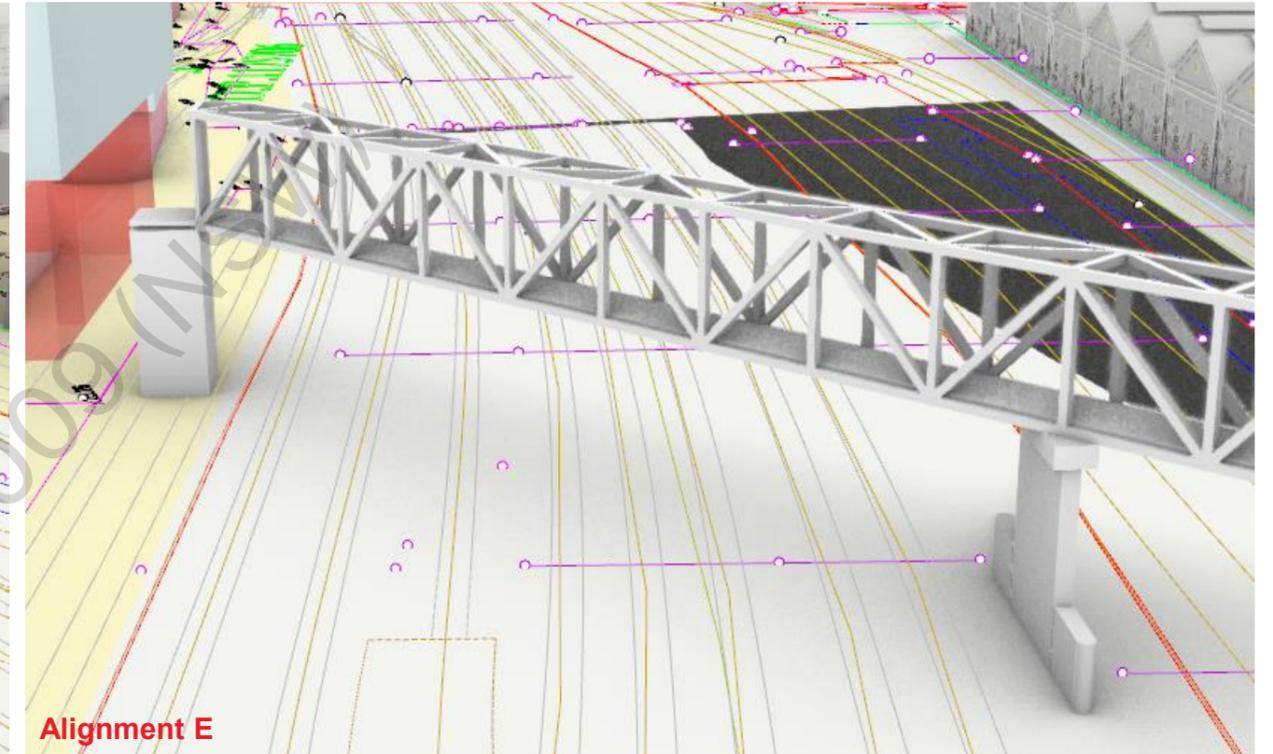
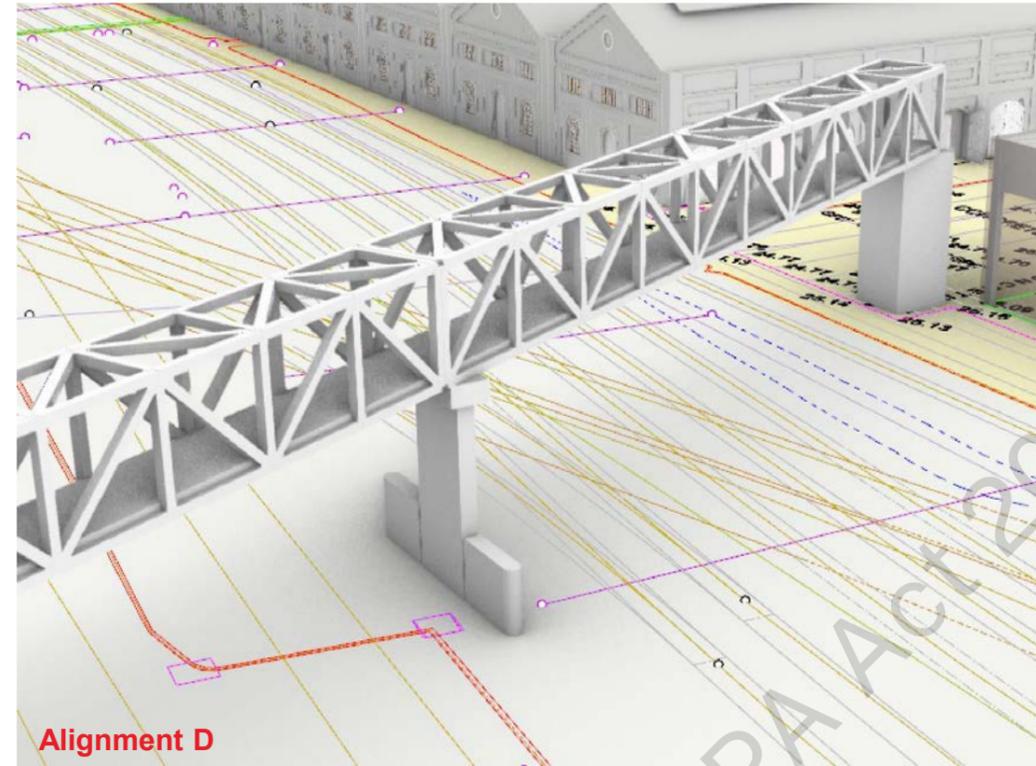
A pier within the rail corridor is required for superstructure options that are efficient and can be lifted into the rail corridor.

Removing the pier is not possible as it would:

- Increase the size of the bridge truss such that access to the full width of the rail corridor itself is required to construct it (not possible).
- Require a cable supported bridge form. However this will require modules to be lifted from the tracks (not possible) and introduces pylons and backstays (not compatible with physical constraints).

Construction of the pier will be challenging and the design will be heavily influenced by the Sydney Trains maintenance regime. The construction duration will be 3.5 years minimum under ideal possession schedules.

Approval from Sydney Trains and AMB is required for any proposed pier.



Piles, pile cap, deflection walls and pier

Cable supported bridge in mass model illustrates back stay clashing with the buildings – not a viable option

** Models are indicative only and do not represent the final forms. The model is intended to provide a visual impression of the structure spatial sizing relative to the site.*

Superstructure - Bridge Volume

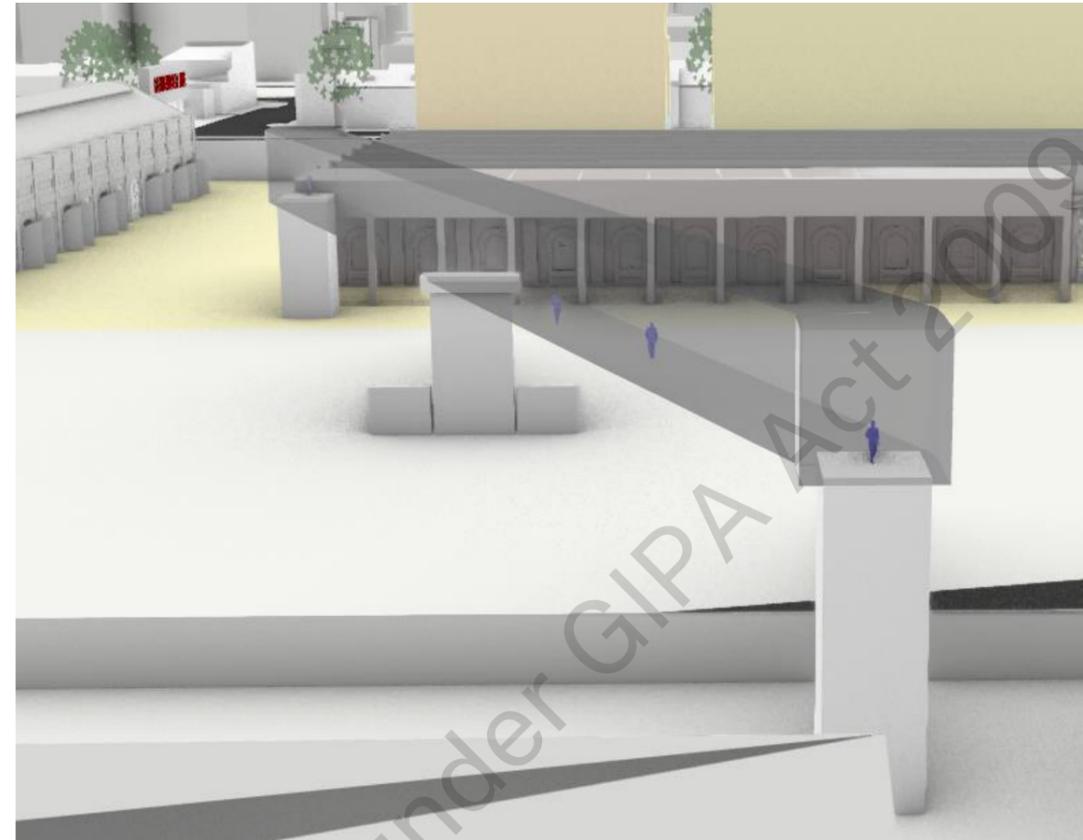
The size of the superstructure is influenced by considerations such as:

- Span
- Self-weight
- Requirement to protect against train stacking

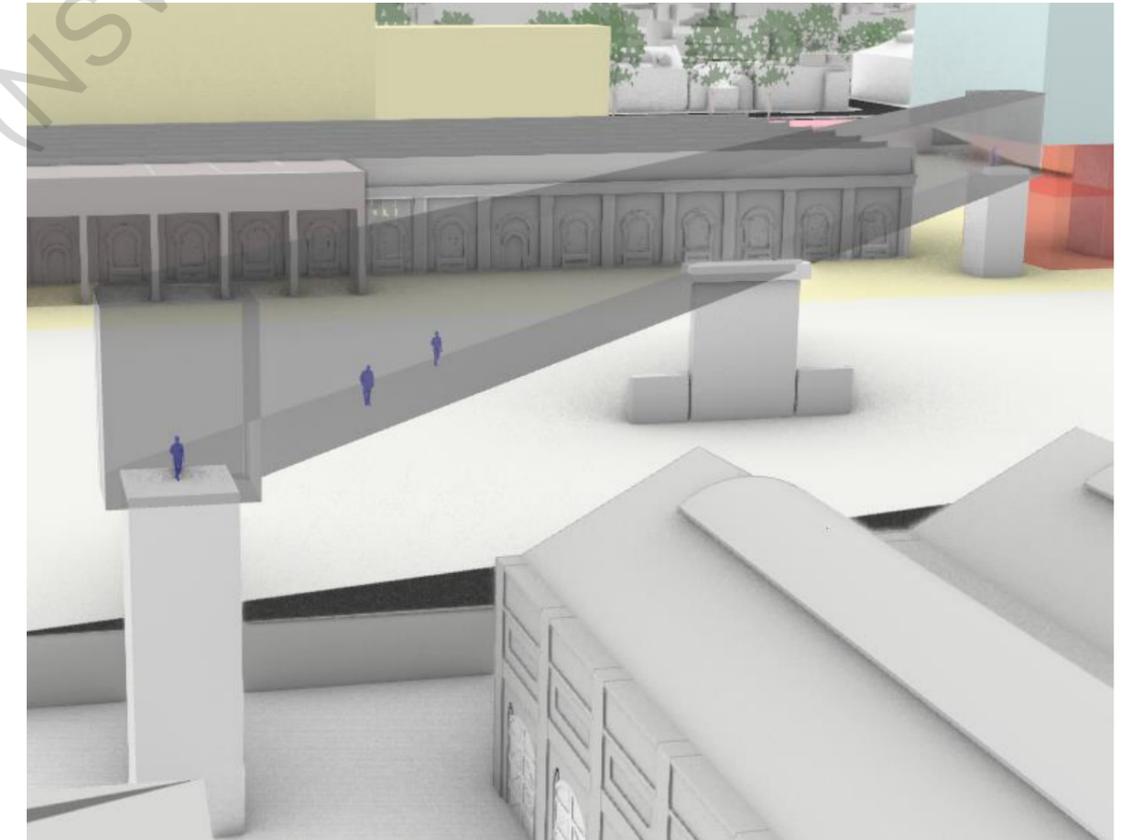
Due the clear spans required, even with the central pier, the bridge will have a substantial structural volume.

It is noted that at this stage, we have focused on practicality, rather than aesthetic appeal. However aesthetics would be an important consideration, particularly in regards to complementing the existing heritage buildings surrounding the bridge.

Alignment D



Alignment E



Indicative dimensions

5m (W) x 5.5m (H)

5m (W) x 7m (H)

Access will primarily be via lifts

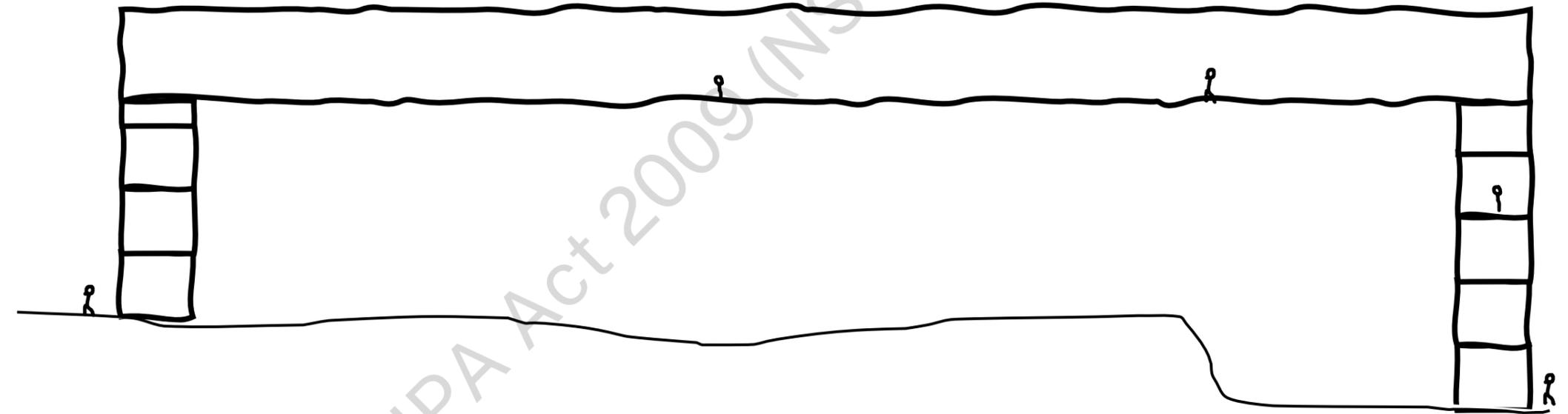
The rise on the north side is approximately 10.5m. This is about 3.5 storeys. (~55 steps/risers)

The rise on the south side is approximately 14.5m. This is about 5 storeys. (~75 steps/risers)
For reference a typical residential storey is 3m.

The bridge alignment provides connectivity for the community. But the stairs also present a cost to pedestrians. At this elevation, the stairs will not be a comfortable or accessible route for many customers. As a guide, stairs are typically used for level changes of up to 5m train stations before they are replaced by escalators and lifts.

The lifts (required for DDA) will be the primary option for access. **Two or more lifts on each end will be required** to meet demand, and multiple lifts will be required so there is backup during breakdown or maintenance. A staircase will still be required in the case of lift breakdowns.

Ramps are not preferred as the elevation and associated horizontal runs present a less-attractive route for pedestrians and cyclists. Refer to future pages for more detail.



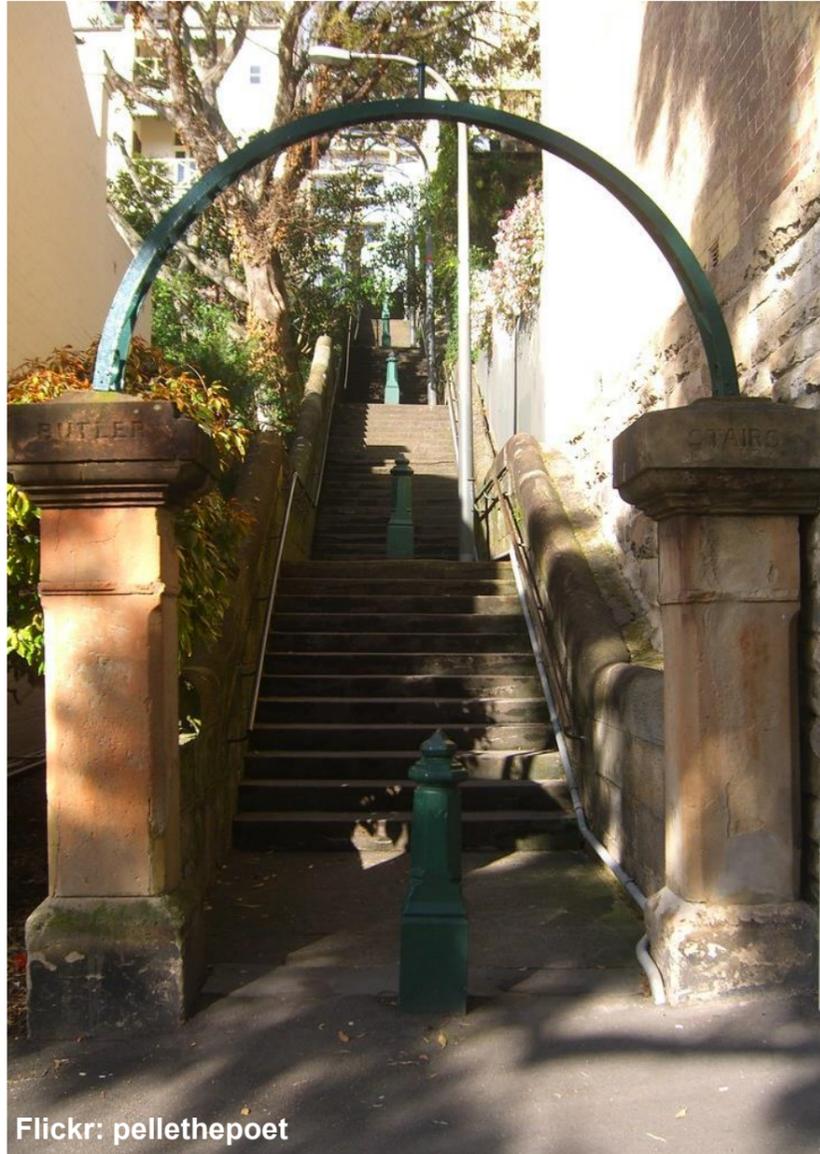
North
10.5m level difference
Approx 3.5 storeys

South
14.5m level difference
Approx 5 storeys

The rise is driven by:

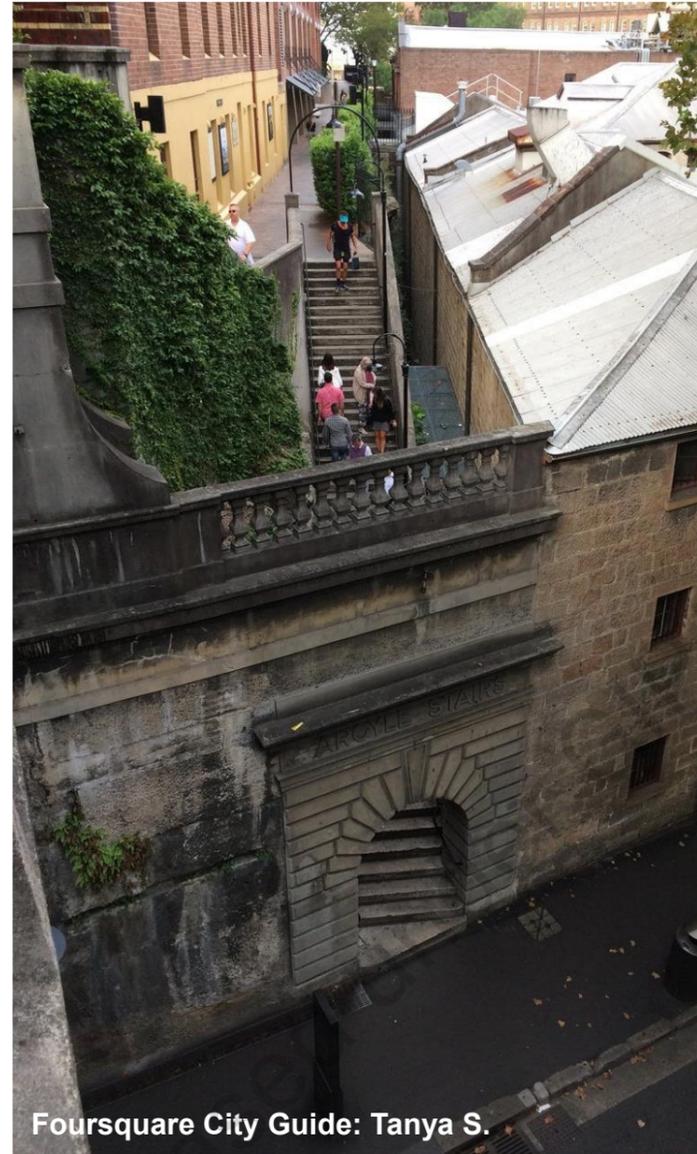
- *Clearance required for rail assets*
- *Clearance for potential train stacking*
- *Level difference - ~3.7m retaining wall*
- *Deck and bottom chord of superstructure*

Local Comparisons



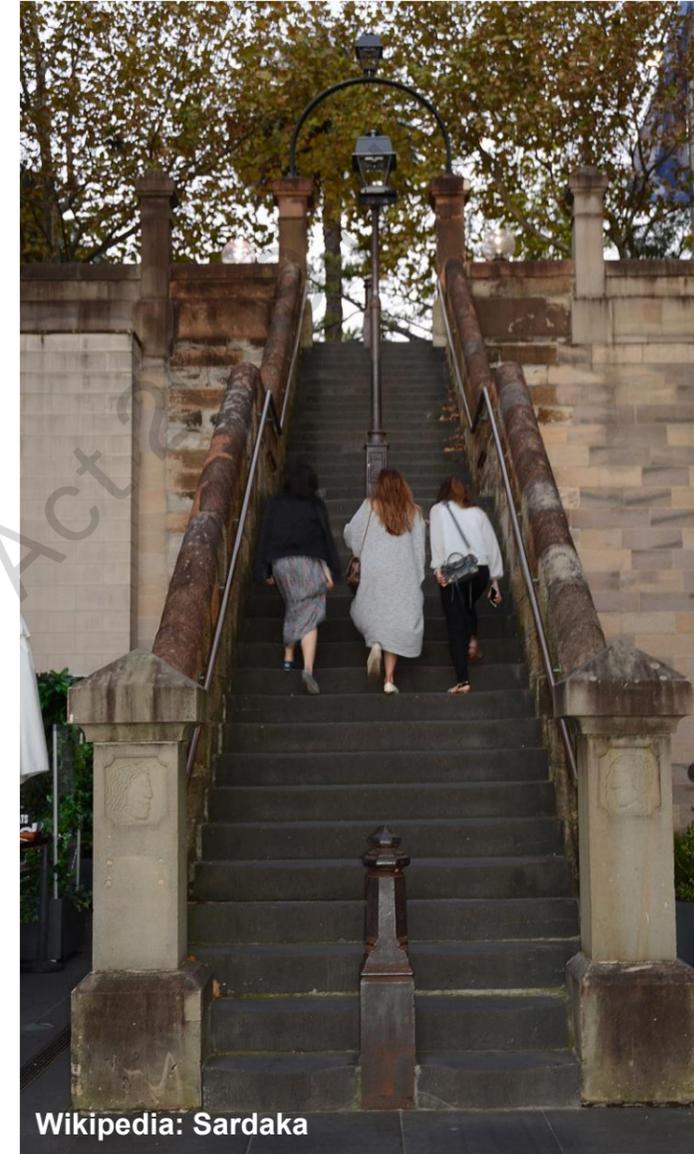
Flickr: pellethepoet

Butler Stairs - connecting the Domain to Woolloomooloo (~19m, 103 steps)



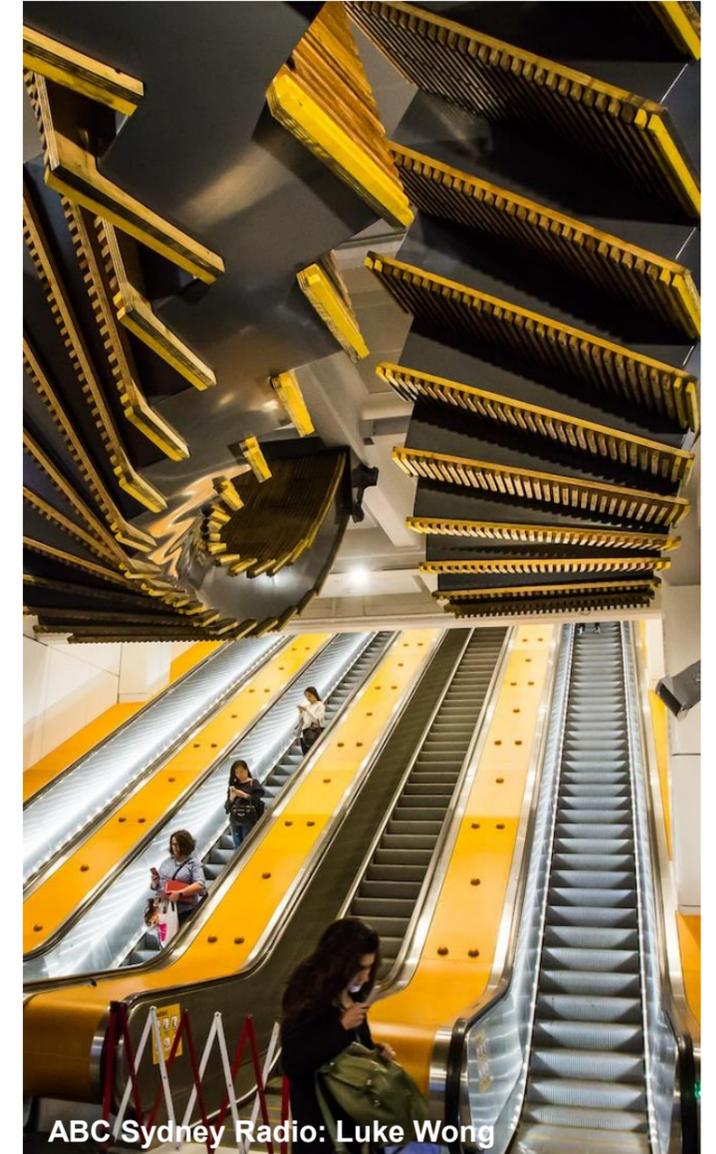
Foursquare City Guide: Tanya S.

Argyle stairs - access from Argyle Street to Cahill Expressway and Sydney Harbour bridge (~10m)



Wikipedia: Sardaka

Moore Steps - connecting East Circular Quay with Macquarie Street (~8m, 38 steps)



ABC Sydney Radio: Luke Wong

Wynyard Station Escalators (~13m)

Note, the general rule of thumb is to use lifts or escalators above 5m.

North: approx. 10.5m, 3.5 storeys, ~55 steps*, 45 seconds#

South: approx. 14.5m, 5 storeys, ~75 steps*, 60 seconds#

*Variable. Depends on step height. Intermediate landings not included.

Highly variable. Depends on individual fitness

South Landing Zone

Both alignments D and E assume a landing zone between the LES and maintenance facility.

The design in the south landing area will require approval from Sydney Trains.

The abutment location has been pushed as close as possible to the rail corridor to:

- Reduce the clear spans
- Maintain a straight alignment
- Avoid clashing with adjacent buildings

NW Route - Access over operational areas

The pier landing is within the Sydney Trains maintenance facility. Extensive engagement and permission will need to be sought from Sydney Trains to secure this location.

Due to the mixed security and safety requirements, an extended deck is needed over the maintenance area so that the lift and stairs can be placed in a publicly accessible zone.



Extended deck over maintenance area

E-W Pedestrian Route

The E-W pedestrian pathway is narrow, and the pier placement will reduce the width of the emergency pedestrian access route. Further, the alignment is not along a major desire line.

The N-S alignment has been considered instead of the E-W alignment.

Impacts for consideration

- Visual impact to adjacent frontage of Locomotive Sheds. The walkway will be visible above the Locomotive Shed roofline.
- Synergies with LES repurposing
- Operational impact to Sydney Trains
- Preserve area under the extended deck alignment for emergency access to the rail corridor
- Refer to next slide for operational impacts

- Rail area
- Publicly accessible area
- Abutment
- Pedestrian access
- Lift/stairs/deck

South Landing – Operational Constraints

The maintenance shed will remain operational. Construction of the south landing becomes challenging with the following operational constraints and requirement at each location, *if endorsement is granted.*

- 1) Access for staff is to remain. Assume the need for emergency exit from Locomotive building for pedestrian access is adjacent to rail corridor.
- 2) Removal of shed is not possible without impacting maintenance operations
- 3) Access to gate is required to be maintained.
- 4) The equipment and shed serve the Locomotive building. Mirvac have easement rights and TfNSW is not in control. Assume no relocation.
- 5) No Parking Zone in front of shed.
- 6) Consideration for turning circles and emergency access to rail corridor.



(1) Staff access



(1) Staff access and area immediately beyond



(2) Shed is used for maintenance



(2) Shed is used for maintenance
(3) Corridor acts as emergency access to rail corridor



(4) Plant for the Locomotive Sheds



(5) Shed access

South Landing - Ramps

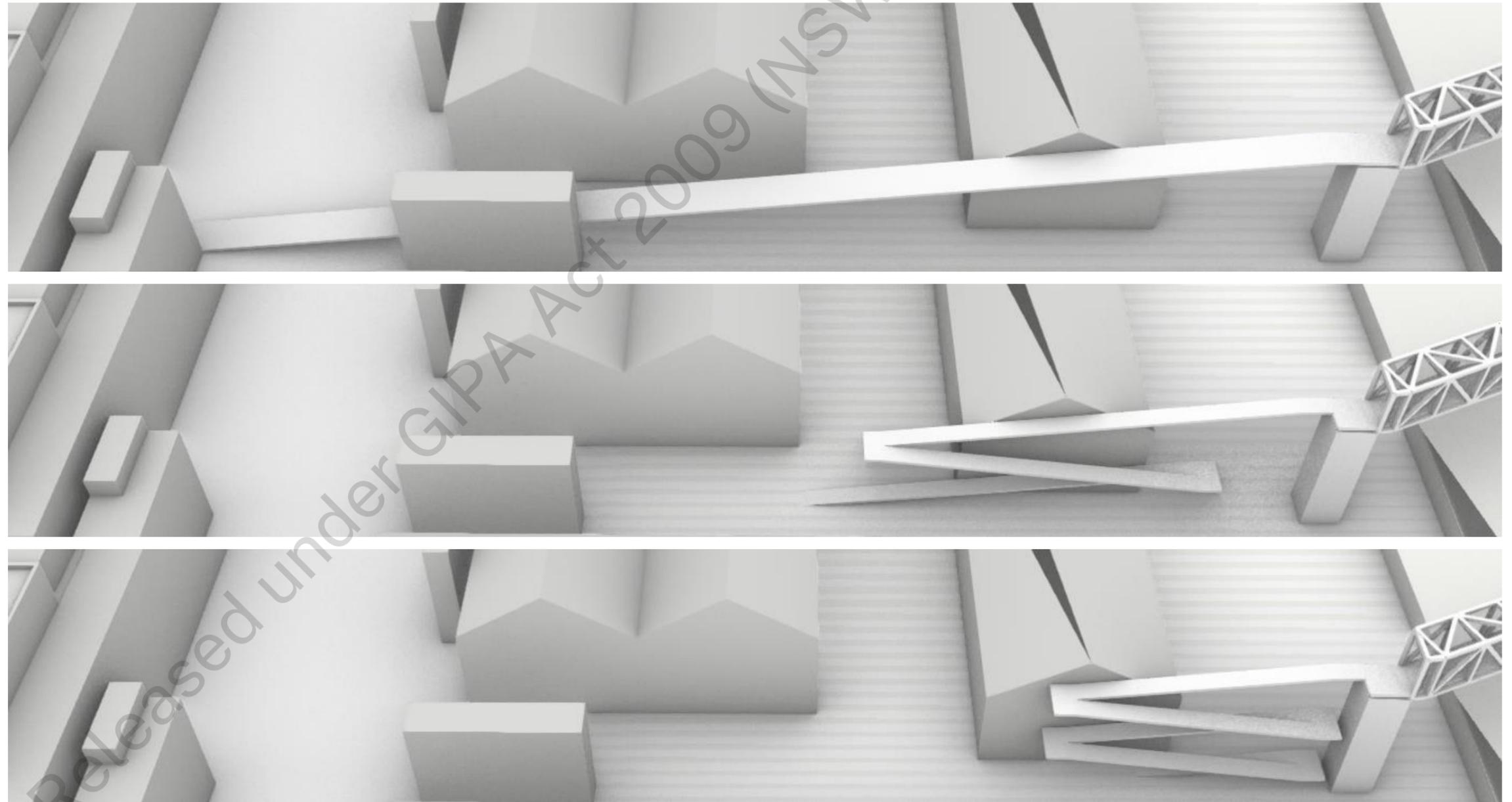
A ramp is not feasible or appropriate for the south landing due to the space required to accommodate the horizontal length given the difference in level.

The steepest grade permissible (Grade 1 in 8 cyclist ramp) without rest zones (not compliant) results in a run to the base of the Channel 7 building. DDA compliant ramps (grade 1 in 20) would be longer still.

For pedestrians, the additional distance increases the walking time and further reduces any potential travel time benefits. For cyclists, the large number of switchbacks reduces the appeal in comparison to a more roundabout but direct route.

A 'winding' run with the large space requirements will also block access to the rail corridor and will present a challenge to an open ground-plane.

Similar typologies would be applied if ramps were used on the north.



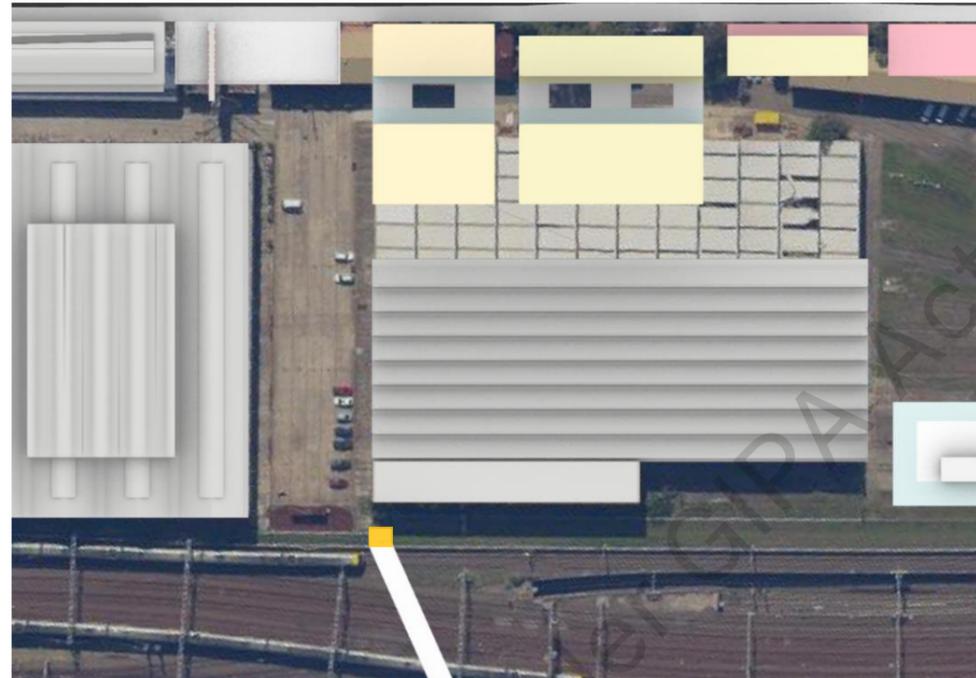
** Models are indicative only and do not represent the final forms. The model is intended to provide a visual impression of the structure spatial sizing relative to the site.*

North Landing Zone

The north landing is slightly less complex than the south, and stairs and lifts will generally fit in the space available. Ramps have not been proposed as a complementary ramp on the south side is unlikely to be accommodated.

A minimum 4m x 4m footprint will need to be reserved for the abutment.

Alignment D
West of Paintshop - Behind Paintshop annex



Alignment E
East of Paintshop



Design outcomes

Respects sight-line along the Traverser.
Potential to direct people into the Paintshop.
May be sited outside the Paintshop precinct boundary.

Potential to direct people into the main square

Constructability

Rail possession or protection will be required to construct the piers.
Proximity to the Traverser gives more storage and lifting space.
Construction will restrict operations of the Carriageworks, and timing of works will need to be coordinated with the availability of the area.

Limited space for access between the Paintshop and K1 building in the new development

Works to be constructed under rail protection.

Very constrained access, will be difficult to maneuver cranes and material if built after the new development.

** Abutment locations are indicative only and do not represent the final forms. The model is intended to provide a visual impression of the structure spatial sizing relative to the site.*

North Landing Ramps

Digital maquettes of the ramps are shown.

As can be seen from the images, a ramp is not ideal as the run required will be a substantial visual impact across heritage frontages.

The scheme shown considers a cyclist ramp (grade of 1 in 8), which has less onerous constraints than a DDA ramp (grade of 1 in 20).

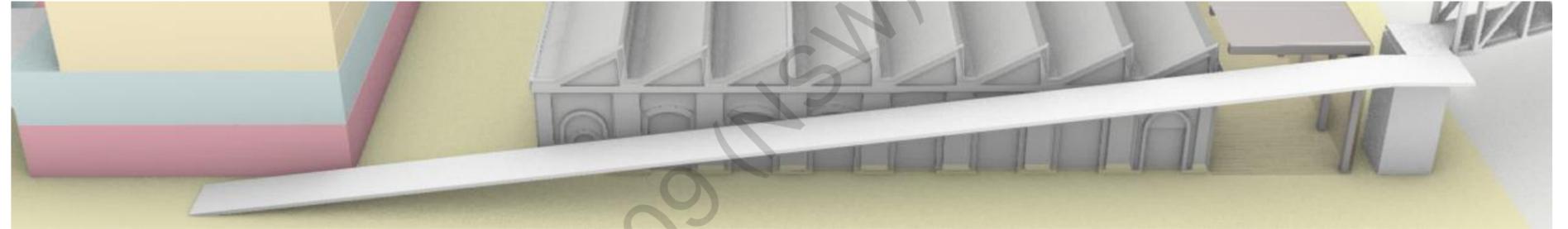
The ramped distance will increase if a DDA ramp is required.

The north landing requires a level drop of approx. 10.5m.

Alignment D West of Paintshop

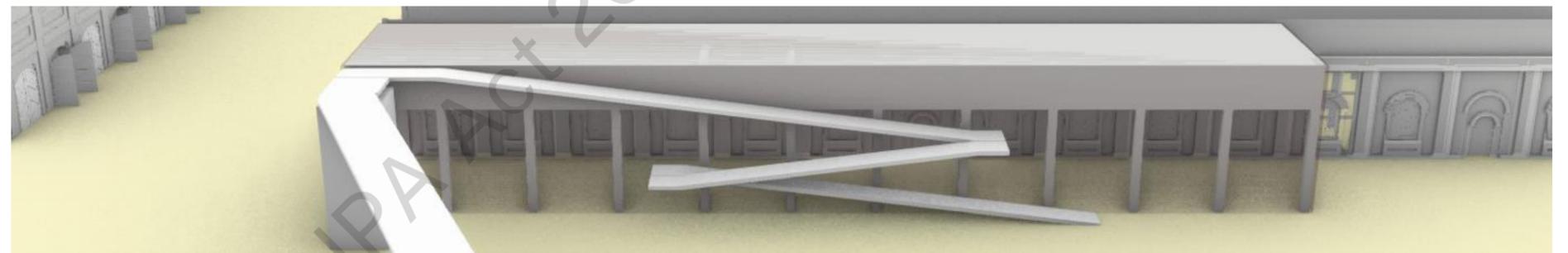
N-S alignment

Will cut across the frontage of the paint shop and along the Traverser, and thus is not desirable heritage outcome



E-W alignment

Coordination required with drainage



Alignment E East of Paintshop

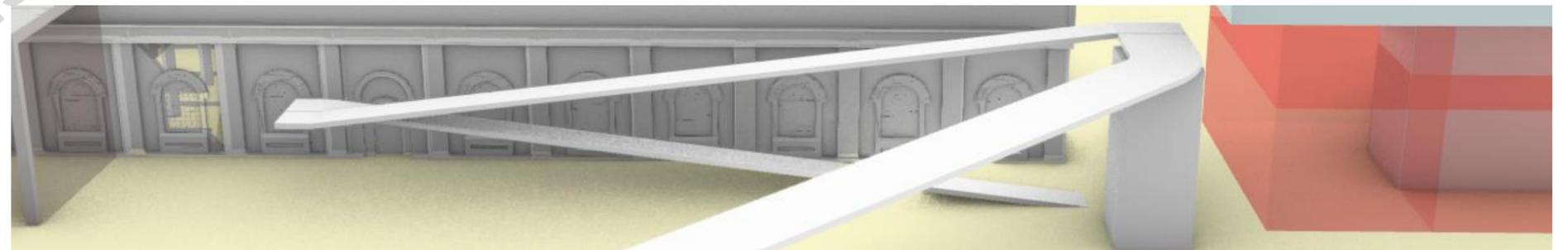
N-S alignment

Will cut across the frontage of the Paintshop and K1 building obstruct the space between Paintshop, and thus is not desirable heritage outcome



E-W alignment

Coordination required with drainage



* The location of the ramp is indicative only and do not represent the final forms. The model is intended to provide a visual impression of the structure spatial sizing relative to the site.

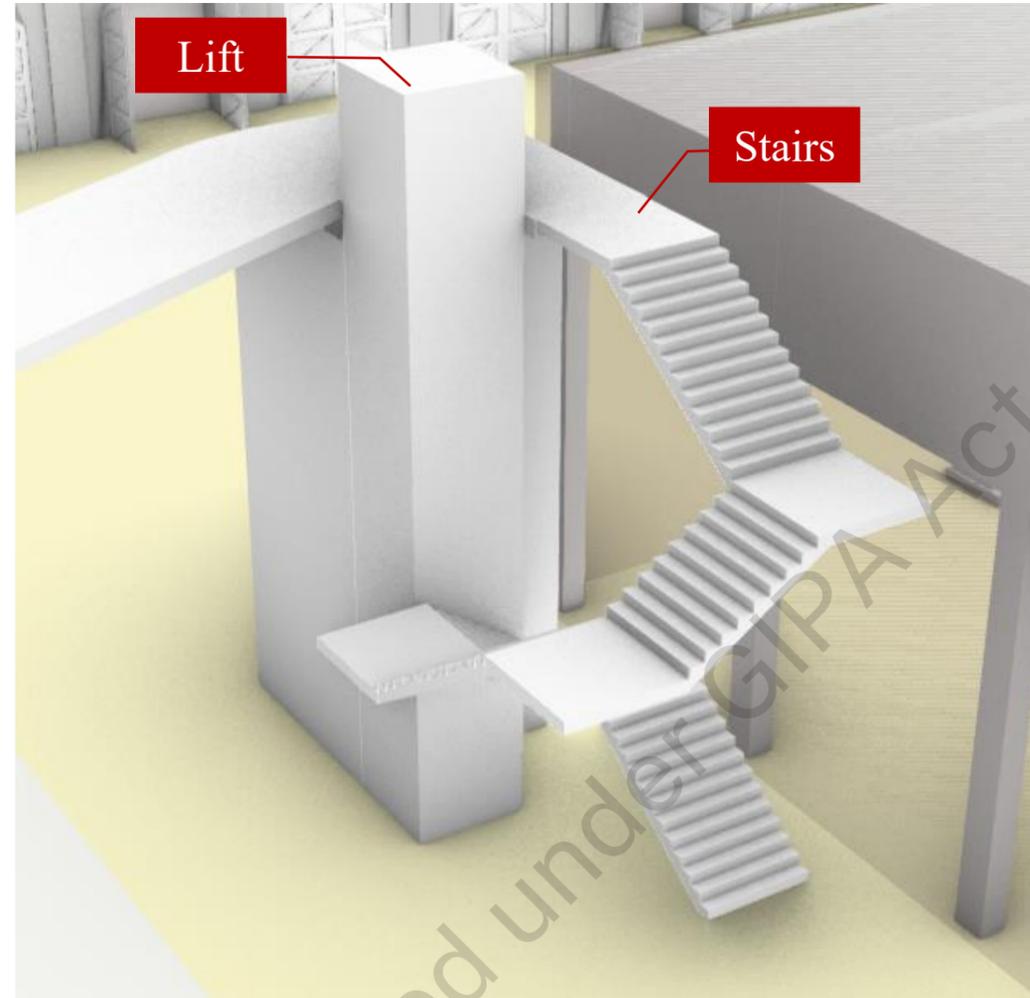
Stairs and Lifts

The configuration and location of the stairs and lifts are TBC at this stage of ideation.

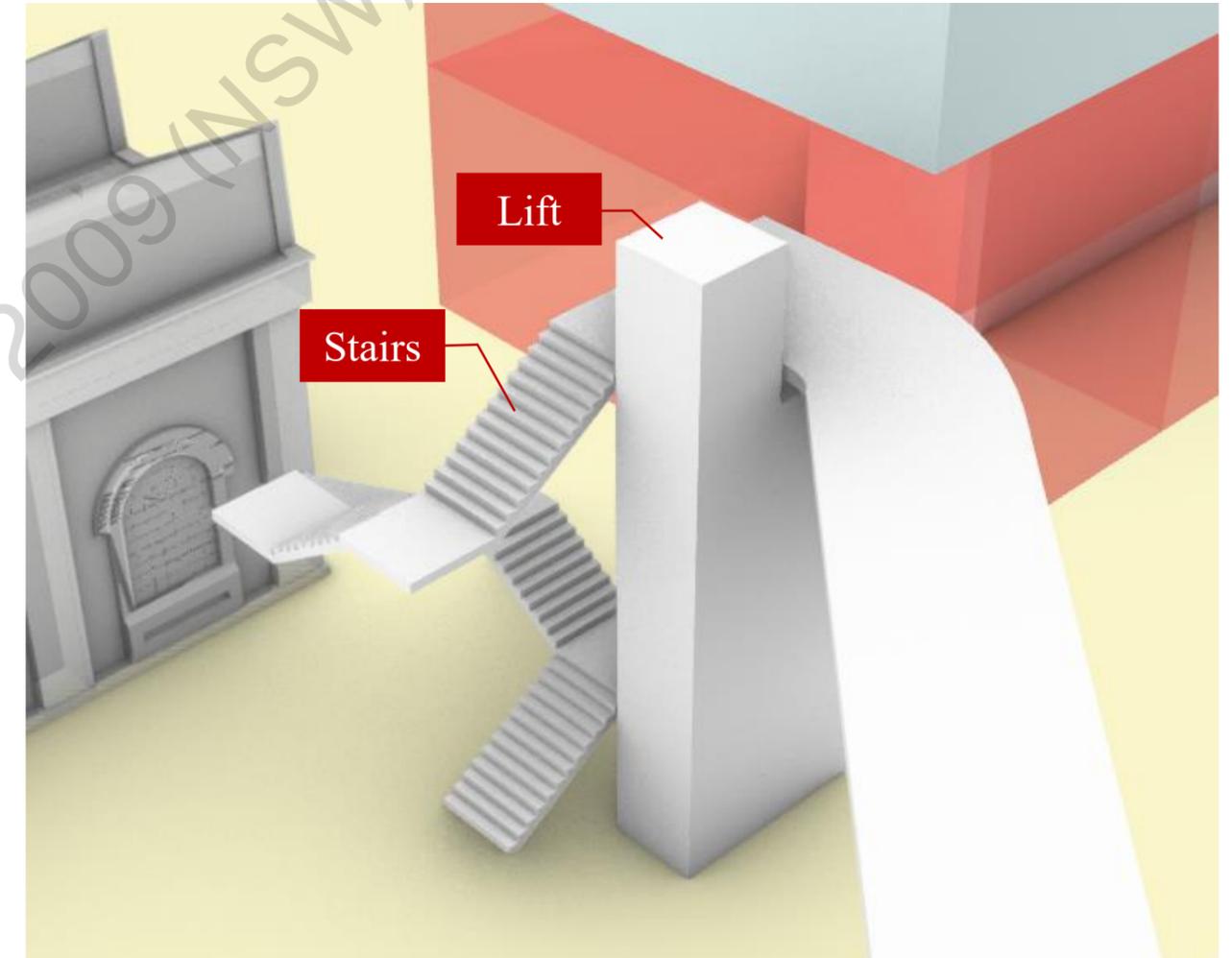
There are multiple feasible configurations available.

It is highly likely they can be accommodated within the landing zones.

Note, the stair is not a mandatory requirement if sufficient lift access can be provided.



Alignment D



Alignment E

** The location of the stairs and lifts is indicative only and do not represent the final forms. The model is intended to provide a visual impression of the structure spatial sizing relative to the site.*

Other Design Considerations

For the bridge to be a safe, comfortable and desirable route for pedestrians and cyclists, multiple other design elements will need to be considered.

A non-exhaustive list of considerations is provided.

	Example Design Considerations
 Safe	CCTV, safety screens/throw screens, Crime Prevention through Environmental Design (CPTED), lighting design above and beyond compliance. Earthing, bonding and electrolysis, consider sightlines for train drivers, risk of train collisions (deflection walls).
 Comfortable	Quality of finishes, maintenance regimes (e.g. cleaning, lift maintenance)
 Convenient	Pedestrian modelling and lift queue times, lift sizing to fit bicycles
 Time Saving	-
 Accessible	DDA
 Sustainability	Embodied carbon, durability and obsolescence.
 Heritage	To be advised, compromise is required.
 Connection to Country	Quality of architectural design, opportunities to tell the story through structural form or non-structural art (e.g. opportunities on throw screens)
 Value for Money	Durability, prefabricated construction
 General Bridge Engineering	Structural design, geotechnical design, utilities (e.g. power connection to service lifts and lighting), drainage, constructability, approvals process through Sydney Trains and AMB

Construction Overview

Constructing the bridge will be difficult, expensive, and take many years.

Due to the location over multiple live rail lines, constructability is a major driving constraint.

Further, due to the proximity of Redfern Station to Central Station, any construction activity will be akin to ‘open heart surgery’.

One high-level and optimistic construction sequence has been outlined.



Construction Considerations

Constructing the bridge will be challenging, expensive, and take many years. Refer to the next page for an indicative construction program.

As the bridge is positioned over a live rail corridor, the construction methodology and sequence will need to be undertaken in alignment with shut-downs or possessions. Each possession typically ranges from 36-48 hours in duration and there are a limited number of possessions granted for each configuration each year. In the ideal scenario, a maximum of 2 possessions will be scheduled for each configuration each year.

Construction activities, including lifts or launch of the bridge, cannot be conducted over live rail, so the majority of construction work will need to be undertaken during possessions. Further, it is extraordinarily unlikely for the entire width of the rail corridor to be shutdown simultaneously, especially for a central artery such as Redfern Station. Staging will need to 'piggy back' off larger projects.

All construction plans will need to be approved by Sydney Trains.

Concessions required

Some elements will explicitly require concessions from Sydney trains. This is a non-exhaustive list.

- Piles and piers in the rail corridor, which would be in proximity to HV assets and the Illawarra Dive.
- A bolted construction project would need to be approved by Sydney trains.

Risks and uncertainties

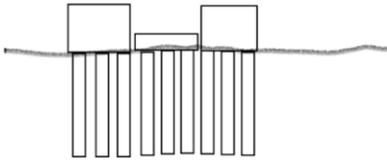
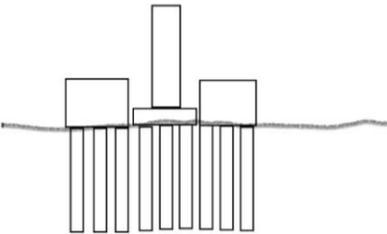
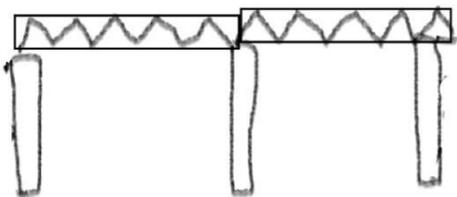
- Possession schedule lookahead is only ~1 year (i.e. no visibility of possessions beyond June 2023)
- Coordination with possession schedule for access and construction.
- Access from the south side is very challenging given that this will cause disruption to the local maintenance facility. If go ahead is granted scheduled work time would still be limited to possession schedules. Access is also required to lift the southern span into place.

Optimistic Construction Program

Under the assumption that up to 2 x 48 hour possessions are granted each year, the bridge has a very optimistic construction duration of 3.5 years. It is highly unlikely that this duration will be reduced, and a more realistic duration would be 4-5 years construction duration. A further 1-2 years needs to be added to account for the design and approvals process.

Risks and uncertainties

- The number of possessions is unconfirmed and may be reduced. The current schedule lookahead is only for 1 year and there is no visibility of possessions beyond June 2023.
- Access from the south side is very challenging given disruption to the maintenance facility. Works within the maintenance facility will also be limited to possession schedules. Access is required to lift the southern span into place.

Bridge element		Possible Min. no of possessions	Min. no of years required for possessions
Piles in rail corridor		2	1
Pile cap install and cast, and set formwork deflection wall		1	0.5
Install pier, deflection wall, concrete pour and strip		1	0.5
Bridge: - Lift and bolt north span - Lift and bolt south span		2	1
Fitout and miscellaneous		1	0.5
Total:		7 possessions minimum	3.5 years minimum

Case Study – North Strathfield Rail Underpass

This case study is provided for consideration only, and a full feasibility study has not been undertaken. At a high-level, a tunnel would have similar constraints on the landing (portal) zones and level differences required as for a bridge. Therefore it would not be a simple and cost effective alternative.

Further, given the foot-traffic and tunnelling distances required (100-150m), a tunnel is unlikely to be perceived as safe. Dimensions, lighting, ventilation finishes and other design elements will need to be of a very high quality/specification if the inherent CPTED challenges of a long tunnel with low volumes of usage is to be overcome.

Overview

- Rail tunnel to grade separate freight trains from suburban trains.
- 148m long
- 8m high x 9m wide
- 2.5 – 3.5m ground cover

Other features

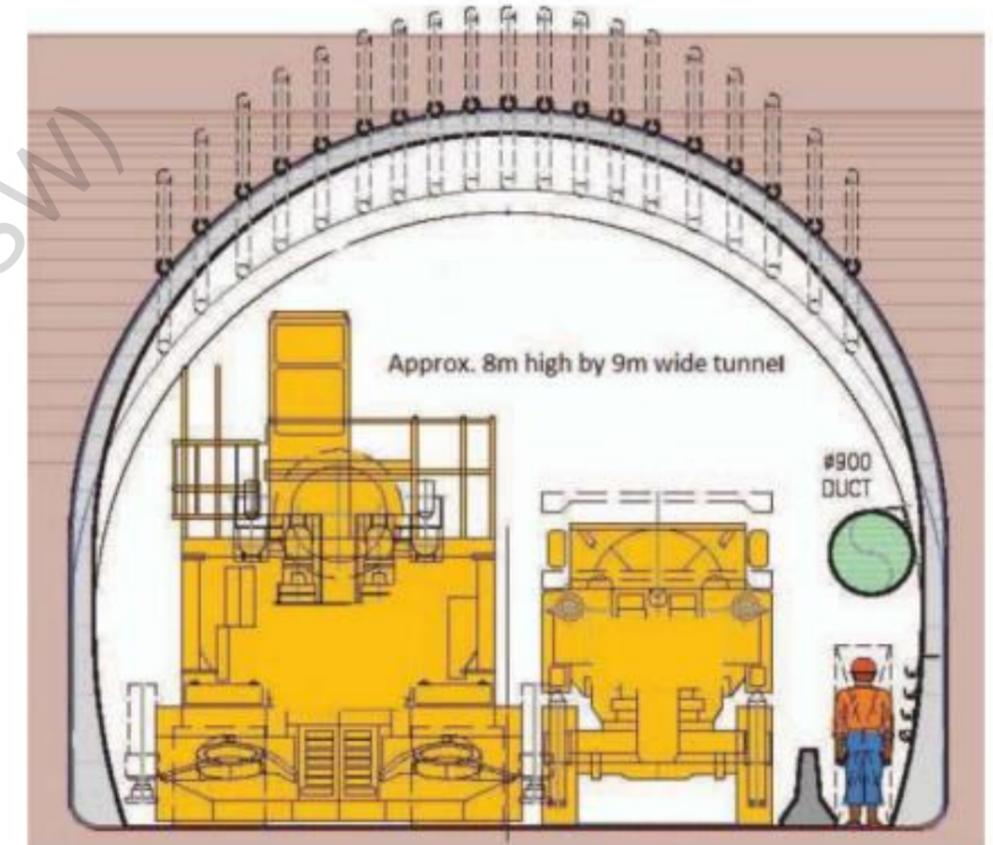
- Geotechnical investigations during track possession regime.
- Excavation cycle - Canopy tube, road header excavation, shotcrete lining.
- Synthetic fibre reinforced shotcrete without steel sets or lattice girders.
- 24-7 monitoring of rail for settlement

Outcomes

- ~6 month tunnelling period
- Limited disruption to rail operations
- Construction adjacent to and under live rail.

Considerations for a pedestrian tunnel at RNE

- Safety and security. Due to length, the end of the tunnel may not be visible.
- Footprint for dive sites
- Interface with existing tunnels or dive structures
- Depth of tunnel and downward ramps



Summary



Summary: Assessment of bridge feasibility

There is a high degree of difficulty in siting and constructing a pedestrian bridge from the RNE development.

The feasibility of the landing zones is questionable, especially on the southern side where the abutments are in operational rail maintenance areas.

The need for possessions and work under protection significantly impacts on cost and programme. Engineering solutions can be found if enough money, time and effort is dedicated to the problem.

However, there is a task for TfNSW to consider whether the cost required to build this bridge is balanced by the use case and benefit it brings to the Redfern North Eveleigh community.

	Connect the North and South Eveleigh communities			Accessible	
	Provide local permeability across the rail corridor			Sustainable	
	Safe			Sympathetic to the industrial heritage of the area	
	Comfortable			Connection to Country	
	Convenient			Value for Money	
	Provide time savings for pedestrians and cyclists				

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Conclusion and Next Steps

The Redfern North Eveleigh Bridge will be a very challenging and expensive bridge to build and does not provide outstanding time savings or convenience for users.

Next steps:

Internal TfNSW benefits and value assessment.

Business case preparation and funding submission (subject to passing value and benefits assessment).

If the bridge is built:

There will be a high cost and long program due to physical and operational constraints.

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Design Costing Notes

The following sections provide further detail to inform cost estimation by the quantity surveyor.



Alignment D [Alignment E]

- From North landing – At west of Paintshop behind the annex [At East of Paintshop]
- To South landing – At zone between maintenance facility and Locomotive Shed



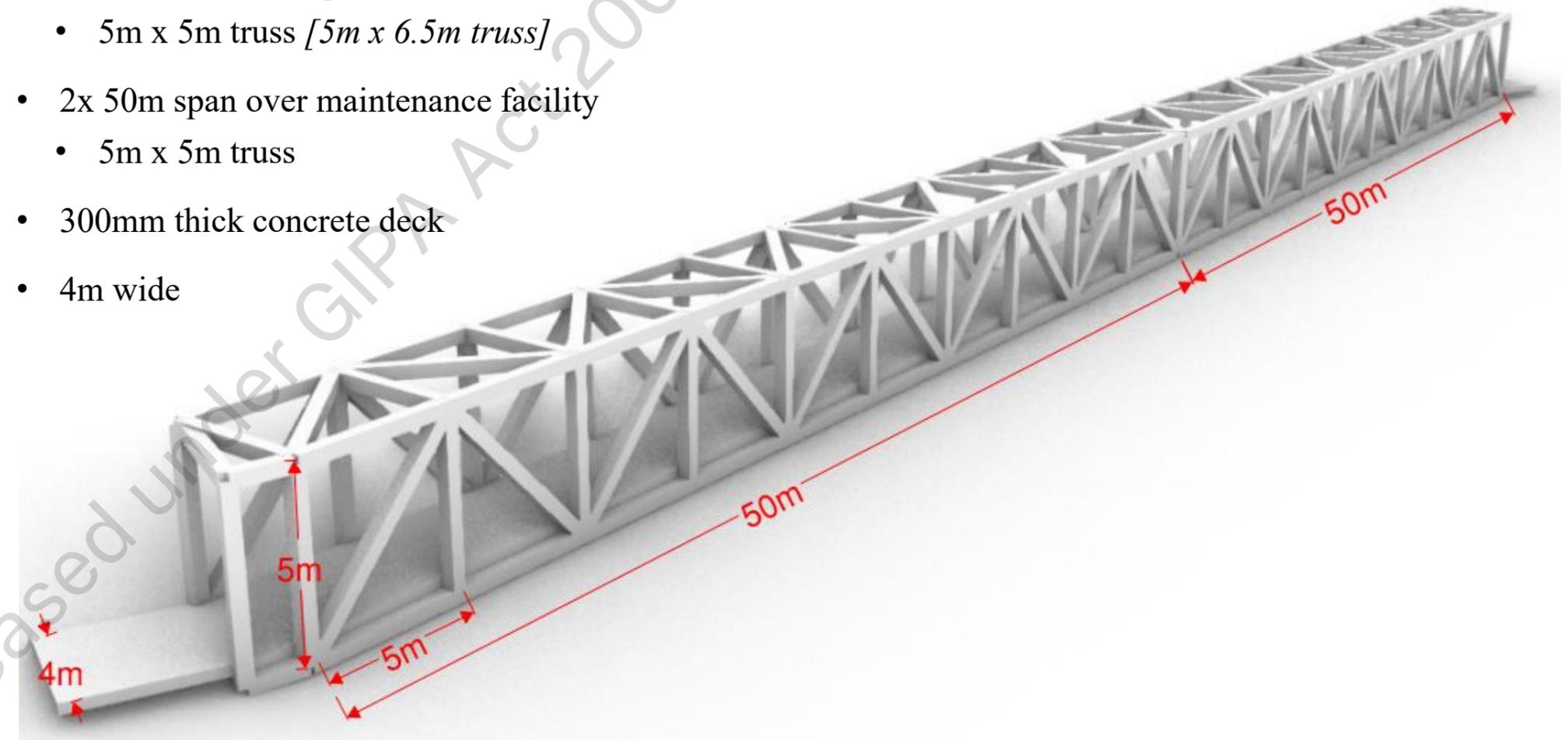
Alignment D

Alignment E

Superstructure Example - Truss

Assumed for alignment D [specific for alignment E]

- Weathering steel for durability and low maintenance preference
- Bolted construction (No site welding)
- 2x 50m [2x 65m] spans over rail
 - 5m x 5m truss [5m x 6.5m truss]
- 2x 50m span over maintenance facility
 - 5m x 5m truss
- 300mm thick concrete deck
- 4m wide
- Access from both the north and the south
- Sloped deck to remove need for drainage
- Skew bridge - 30 degrees [45 degrees]



Truss in Alignment D and for spans over maintenance facility in both alignments

Bridge Detail

Notes on Scheme Design for Costing

Substructure

Assume for alignment D
[specific for alignment E]

- 2x Abutments
 - Minimum 4m x 4m footprint
 - Abutment foundation
 - From top of deck to ground, approximately 10.5m at North and 14.5m at South
- 1x Headstock*
- 1x Pier in rail corridor*
 - Precast, post-tension
- 2x Deflection wall
- Pile caps*
 - Separate pile cap under pier and deflection walls
- 8x Piles *[9x Piles]*

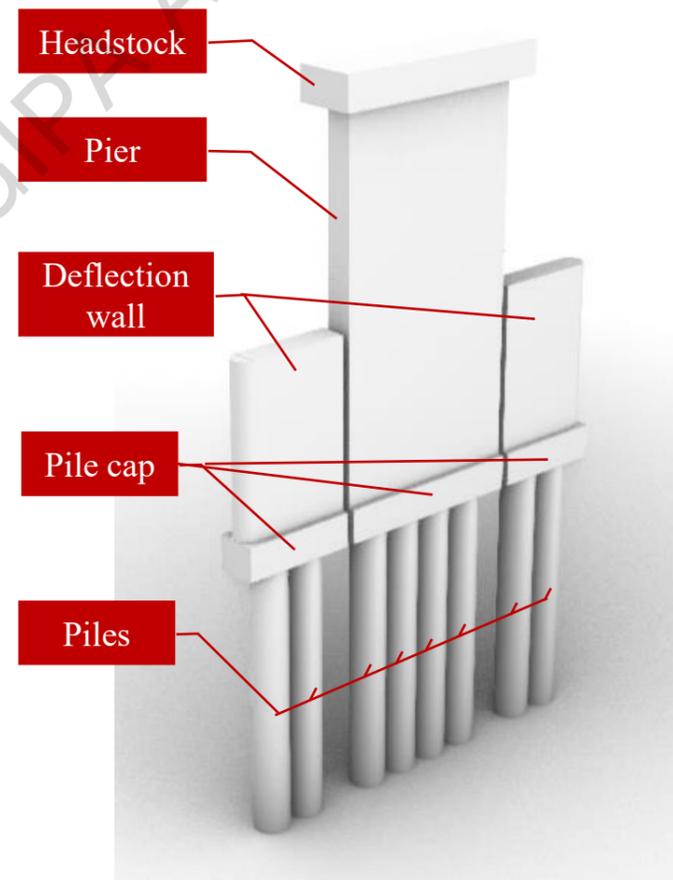
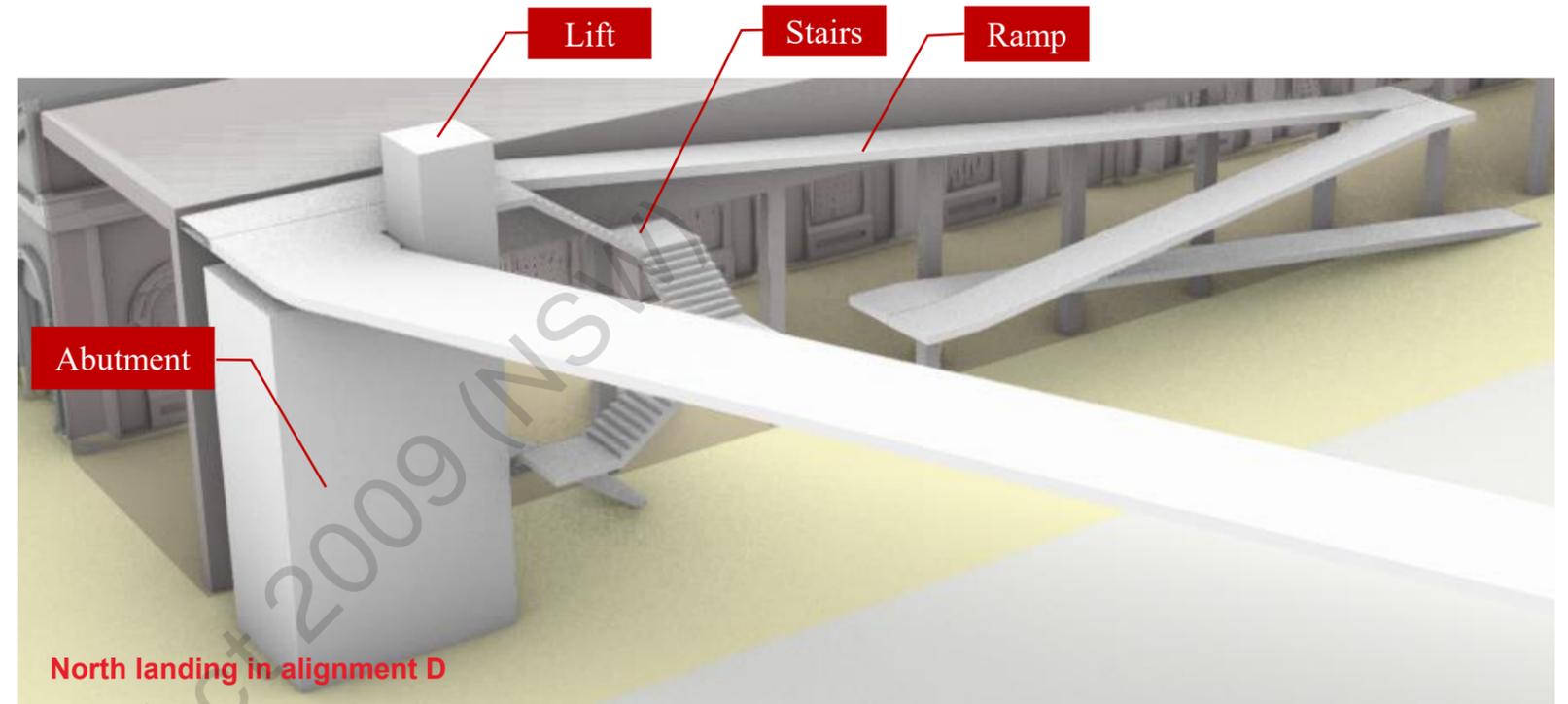
* Headstock, pier and pile caps will be larger in size for alignment E

Access, Fittings and Others

- Access at each landing (See abutment for required level drop)
 - Lift (2x each side, assume 13p lift to fit a typical bike)
 - Stairs (Assume 1.6m wide)
 - Ramps (note as separate line item)
- Handrail
- Safety screen
- Lighting (assume specialist lighting over and above compliance requirements)
- Security (CCTV)
- Include additional allocation for Connection to Country piece.

Superstructure

- Needs to be of a very high aesthetic quality
 - E.g. similar to Lachlan's Line or Helix Bridge in Singapore



* The location of the ramps, stairs and lifts is indicative only and do not represent the final forms. The model is intended to provide a visual impression of the structure spatial sizing relative to the site.

Bridge Detail

Construction Costing Notes

The following sections provide further detail to inform cost estimation by the quantity surveyor.



Substructure

Construction of the substructure will require a combination of the following:

- Full rail possessions to construct the central pier
- Approval to perform construction work close to HV asset and Illawarra Dive
- Work under protection to construct the abutments
- Substructure design is possession-driven, hence time-efficient solutions are proposed that can be constructed within the available possession.
- Work in the rail corridor will require temporary rail access by flooding the track with ballast to allow access for a piling rig and trucks from the northern side of the site.

Substructure	Construction method	Other risk and assumption
Pile	<ul style="list-style-type: none"> • Bored with temp casing. Remove soil • Install pile reo cage with crane • Cast concrete pile in place 	<ul style="list-style-type: none"> • Assumed cased bored pile • Unknown rock level. Founding level to be determined from GI • Potential contaminated material in bore • Piling rig must achieve clearance underneath de-energised OHL
Pile cap	<ul style="list-style-type: none"> • Precast concrete or steel shell casing as formwork – temp shoring • Lift in place • Prefabricated reo cage • Concrete pour from long reach pump on the northern side or along tracks via Mcdonaldtown 	<ul style="list-style-type: none"> • Steel shell can be used as a sacrificial formwork • Assumed the shell can be transported to site
Pier / Deflection wall	<ul style="list-style-type: none"> • Precast segments lifted in place • Tie to pile cap with Macalloy bar • Grout <p>OR</p> <ul style="list-style-type: none"> • Formwork / Transvent tube left in corridor • Prefabricated reo cage on site • Concrete pour 	<ul style="list-style-type: none"> • Precast unit would be the time-efficient option. However, the size of the unit can pose an issue for transportation, and it is a heavy lift. • Risk of clashing with OHW and gantry during lifting and working at top of pier
Headstock	<ul style="list-style-type: none"> • Precast concrete or steel headstock lift in place • Install bearings 	<ul style="list-style-type: none"> • Risk of clashing with OHW and gantry during lifting
Abutment	<p>For foundation</p> <ul style="list-style-type: none"> • Excavate the desired footprint • Form reo cage/ steel fixing on site • Concrete pour • Construct abutment structing once concrete is cured and other fitout, including cladding 	<ul style="list-style-type: none"> • Approval to construct adjacent to the Paint Shop Precinct boundary for north abutment • May require rail possession as the abutment location is close to the railway track, subject to coordination with Sydney Train. Alternatively, the work must be performed under protection.

Substructure

Crane and Access

- Mobile crane is preferred due to limited space and relative ease of mobilization. Constructability is assessed based on the use of 450-tonne mobile crane.
- Load capacity is approximately 30t for 30m and 20t for 40m reach.
- Requires a 3.1m width clearance for travel and access.
- Requires approximately 20m long x 10m wide area for crane setup with outriggers

Bridge design requirement

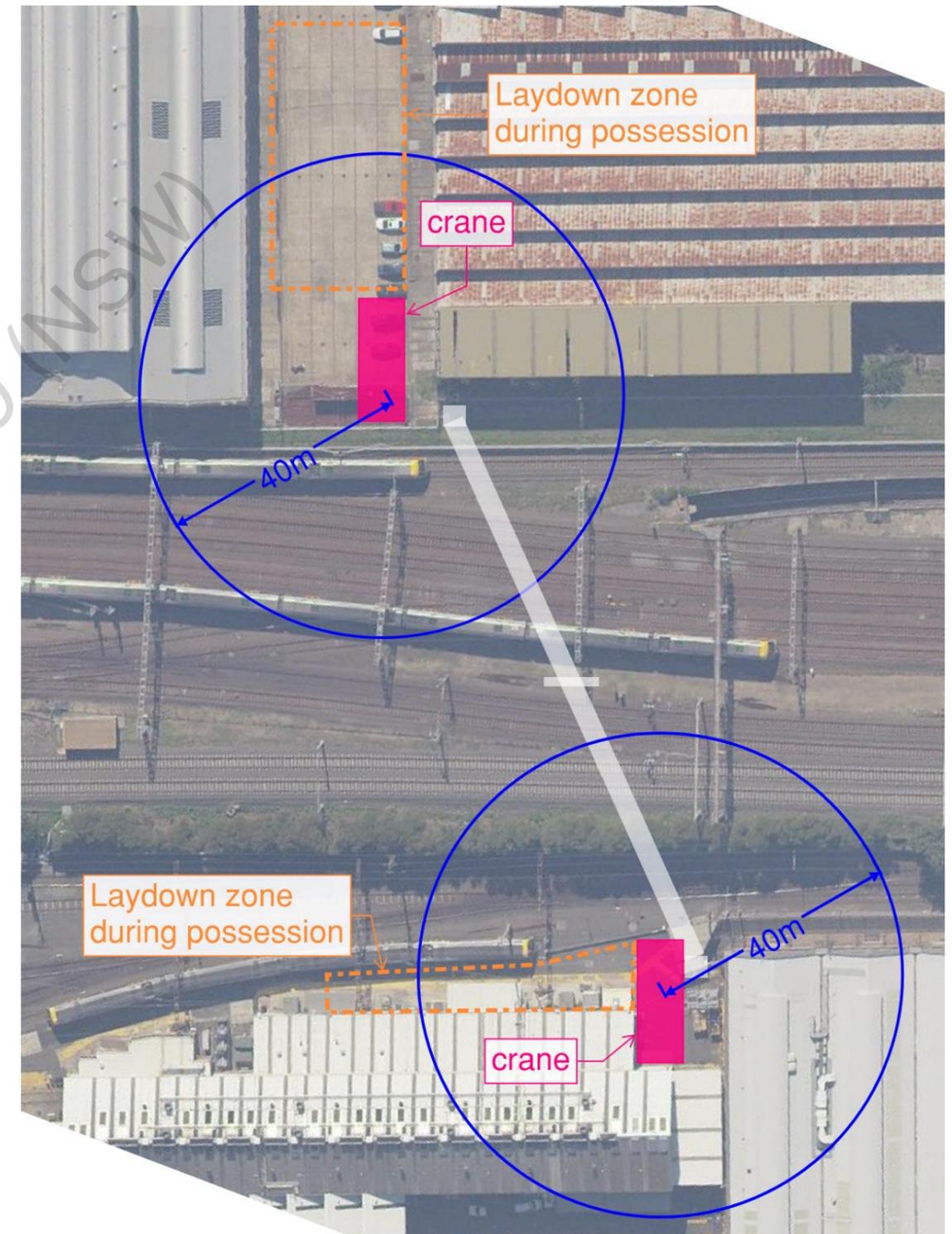
- Weathering steel
- Bolted design – no welding
- Subject to the final design, the bridge may be designed into smaller segment with bolted connection. This reduces the weight for the lift.
- Each segment can be designed in different size/length due to the allowable lift weight in the reach, say 20-35 tonnes each.

Lifting Process

1. Lift bridge in place in modules (2 x vertical trusses and cross members)
2. Modules are bolted.
3. Concrete deck poured on transfloor.
4. Once concrete is cured, fit out work can commence, including installing handrail, safety screen, lighting etc.

Risks and assumptions

- The Traverser can be utilised in the north as laydown and storage area
- Carriageworks access along the Traverser will be affected during construction (e.g. substantially during possessions, and partially affected between possessions).
- Heavily dependent on Sydney Trains approval for maintenance area access. Will need to temporarily remove shed and other obstacles for crane access and bridge parts assembly. Very tight laydown zone, constraint in space for access. Assumed that construction access in this area will be during possession regimes and not for the entire elapsed construction period.
- Lifting bridge segments over building.



Superstructure

Possessions

Construction of the pier in the rail corridor and superstructure erection will require rail possessions.

The current possession schedule (issued on 23 Sept 2022) indicates plans up to 25 June 2023. There is no visibility on the future schedule .

Assuming the future schedule is comparable to the current possession schedule, we have assumed:

- 2 possessions a year
- 48 hours in each possession
- minimum 7 possessions is required, suggesting a **minimum 3.5 - 4 year construction period**

The construction of other bridge components (abutment, access) has not been considered as part of these rail possessions but will be constructed under possession.

Negotiation may be possible with Sydney Trains regarding whether the bridge construction schedule can be considered in the future possession schedule planning. An allowance may be made for additional possessions. However, it is unlikely that the project will be granted 'ideal' possession configurations and the project would likely need to "piggy-back" on other larger projects.

Construction sequence by element	Min. no of possessions	Remark
8x no. of piles	2	<ul style="list-style-type: none"> • 4 piles per possession • 2 rigs required
Pile cap	1	<ul style="list-style-type: none"> • Precast unit or steel shell can be used as a sacrificial formwork • Drop reo cage/ steel fixing on site • Concrete pour
Pier and Deflection wall	1	<ul style="list-style-type: none"> • Formwork for deflection wall shall be set in previous possession • Pier can utilise Transvent tube as the formwork • Drop reo cage/ steel fixing on site • Concrete pour
Headstock and Superstructure	2	<ul style="list-style-type: none"> • Crane required • Headstock and superstructure will be lifted in place • Including bearing installation • One possession per lift from north and south • Bolted design and no welding
Fitout and miscellaneous	1	<ul style="list-style-type: none"> • Cast deck slab, install safety screens, lighting etc
Total:	7	

Rail Possessions for Construction

Other notes for costing

- Replacement bus during rail possession may need to be allowed for
- Protection cost – protection officers
- Use of temporary access structure or to flood the track for piling rig and truck access on tracks
- To permanently/temporarily dismantle or relocate shed and entry access hub in the south landing
- Cost risk due to no future possession schedule for contractor planning
- Maintenance facility must remain operational. Assume construction under protection for south-side deck between LES and Loco.
- Ground investigation is required. Shallowest rock depth is 8m to 15m. With the shallower depth at the northern side. Rock is dipping towards the south based on desktop studies of the site. Pile lengths TBC. Rock sockets would be required.
- Assume contaminated fill throughout.

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Other Notes

About Us

The analysis and report for this project was undertaken by Arup who have significant experience with analysing the design and performance of bridges and rail infrastructure.

References + Standards

To complete the analysis and reporting, a series of standards and documents were reviewed and considered as part of the process.

The following standards were used as references:

- AS5100-2017 - Bridge Design
- BTD 2012/01 - Provision of Safety Screens on Bridges
- ESC215 – Transit Space
- EP 08 00 00 01 S - Overhead Wiring Standards for the Electrification of New Routes
- T HR CI 12030 ST - Overbridges and Footbridges
- T HR EL 10001 ST - HV Aerial Line Standards for Design and Construction
- T HR SC 10001 ST – Signalling Design Principle

The following documents were referred to:

- Eveleigh Heritage Walk *for Redfern Waterloo Authority* [2008 study]
- Carriageworks to Australian Technology Park – North-South Pedestrian Link *for Urban Growth* [2017 study]

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Redfern North Eveleigh

Transport for New South Wales

Tunnel Option Briefing Note

6 February 2023



Existing Maintenance Tunnel

There is an existing heritage maintenance tunnel crossing from the Carriageworks towards South Eveleigh.

However, it does not fully cross the rail corridor.

Northern tunnel portal is not easily made accessible to public, and inconveniently located with very restricted access between the Carriage works and the rail tracks, as indicated in image below.



Existing Maintenance Tunnel

A 'tunnel' was indicated diagrammatically and described briefly in various sources of drawing and reports.

The tunnel does not fully extend across the rail corridor. It runs from the south-side of the Carriageworks and towards the western end of the LES but emerges onto rail track. The northern tunnel entrance is not visually obvious and inconveniently located.

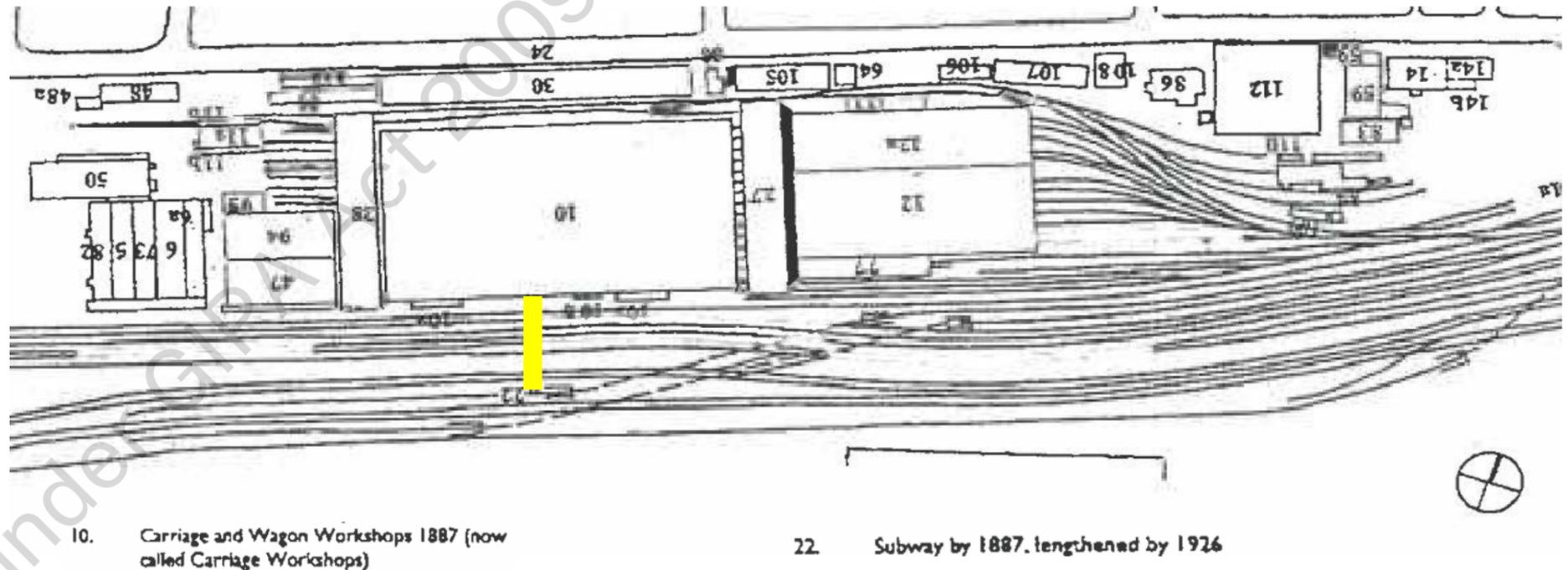
The ability for an extension of the tunnel beyond the southern boundary of the rail corridor will be limited as this will require major disruption to rail services given the presence of the Illawarra Dive and the operational nature of the tracks.

The NSW Office of Environment & Heritage provides the following description under Eveleigh Railway Workshops, listed under s.170 Register.

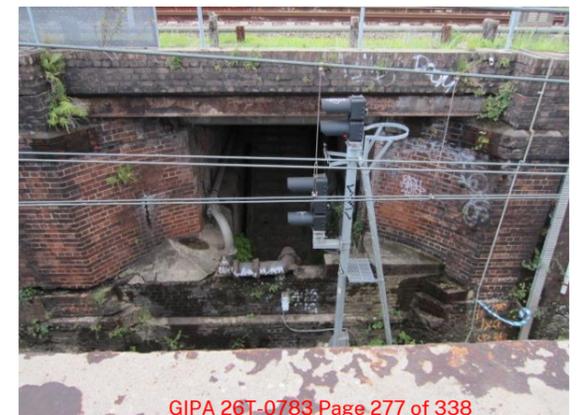
Heritage Description: S34: Eveleigh Yard Subway (1925-1927): The subway is a rectangular tunnel 80 metres in length, running below the rail tracks between the Carriage Workshops and the Loco Workshops at Eveleigh. Walls are brick lined and the floor and ceiling are concrete. Both ends are accessed by a flight of brick steps from ground level and there is one flight of steps within the tunnel, near the southern end.

Further the tunnel is also included in the Heritage Conservation Management Plan for the area resulting in potential difficulties and constraints.

As the tunnel has a low height and width, unlined and unventilated, additional investigation will be required to assess the current condition and internal dimensions of the tunnel to determine whether the tunnel is suitable to meet requirements of a modern pedestrian tunnel, which is not considered likely.



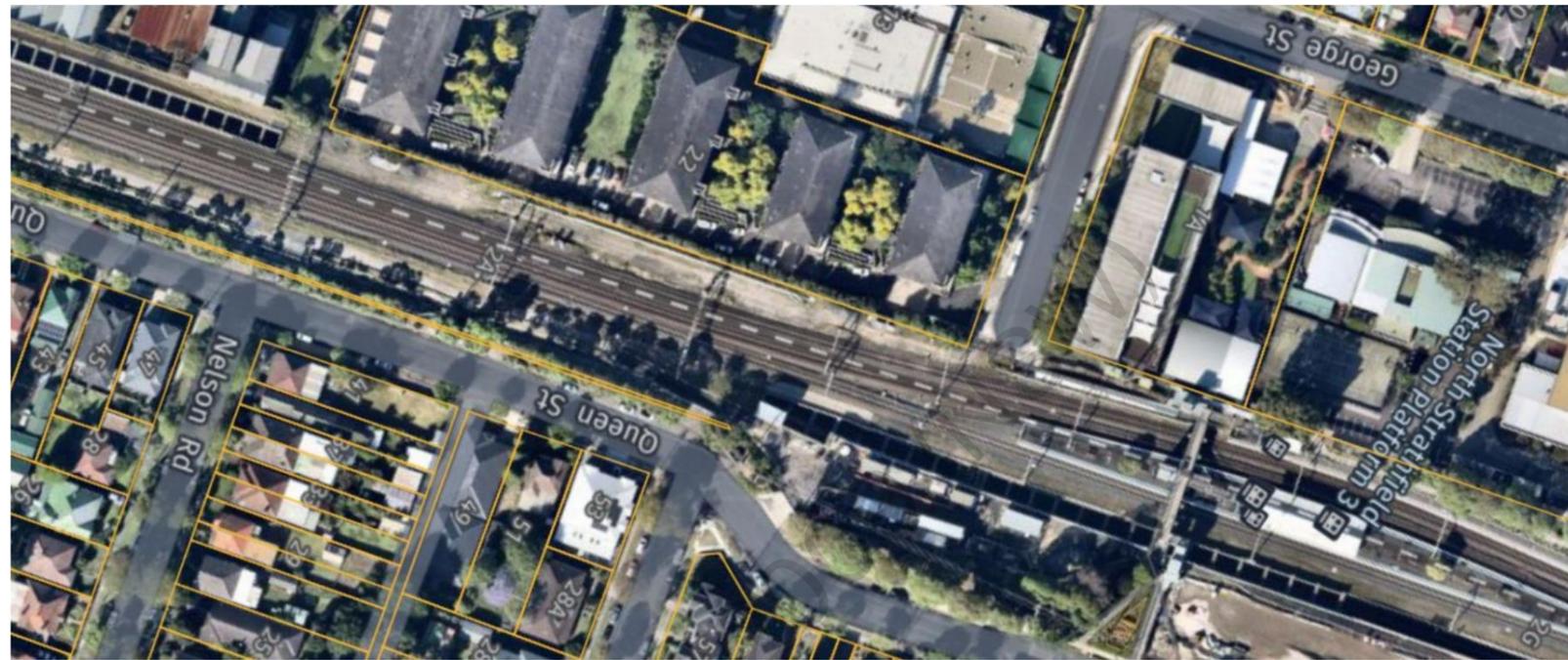
Statement of Heritage Impact - Carriageworks at Eveleigh Contemporary Performing Arts Centre (2003) Subway location in yellow



Tunnel Case Study

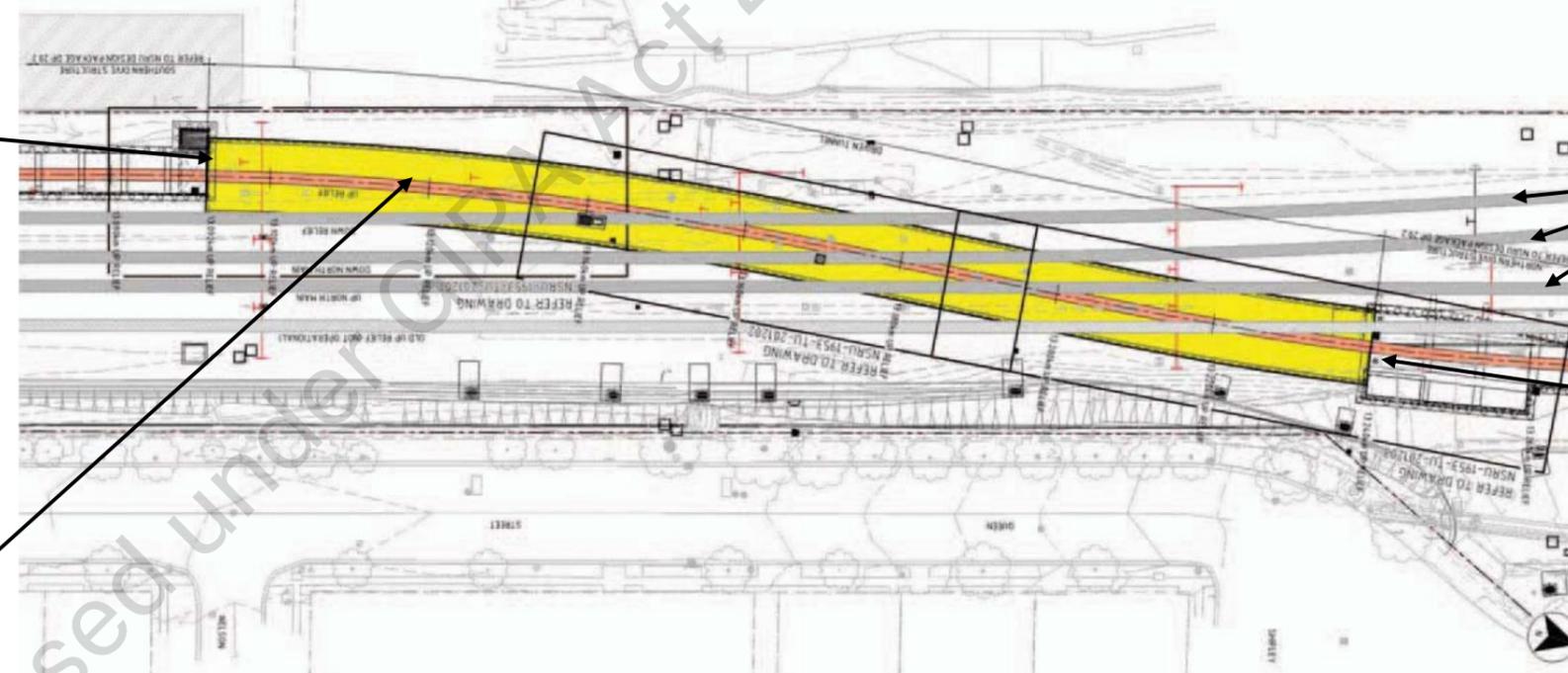
The North Strathfield Rail Underpass was built as a rail tunnel, rather than a pedestrian tunnel. However it provides insights for constructing under live rail.

Gonzalez, M. et al., 2014, *The North Strathfield rail Underpass – Driven Tunnel Design and Construction*, 15th Australasian Tunnelling Conference 2014, Sydney, NSW, 17-19 September 2014.



Southern tunnel portal

Alignment of tunnel



Existing operating railway lines

Northern tunnel portal



Case Study – North Strathfield Rail Underpass

This case study is provided for consideration only, and a full feasibility study has not been undertaken, and serves as an example for a tunnel being constructed immediately below a live rail environment. At a high-level, a tunnel would be have similar constraints on the landing (portal) zones and level differences required as for a bridge. Therefore it would not be a simple and cost effective alternative.

Further, given the foot-traffic and tunnelling distances required (~300m), a tunnel is unlikely to be perceived as safe. Dimensions, lighting, ventilation finishes and other design elements will need to be of a very high quality/specification if the inherent CPTED challenges of a long tunnel with low volumes of usage is to be overcome.

Overview

- Rail tunnel to grade separate freight trains from suburban trains.
- 148m long
- 8m high x 9m wide
- 2.5 – 3.5m ground cover

Other features

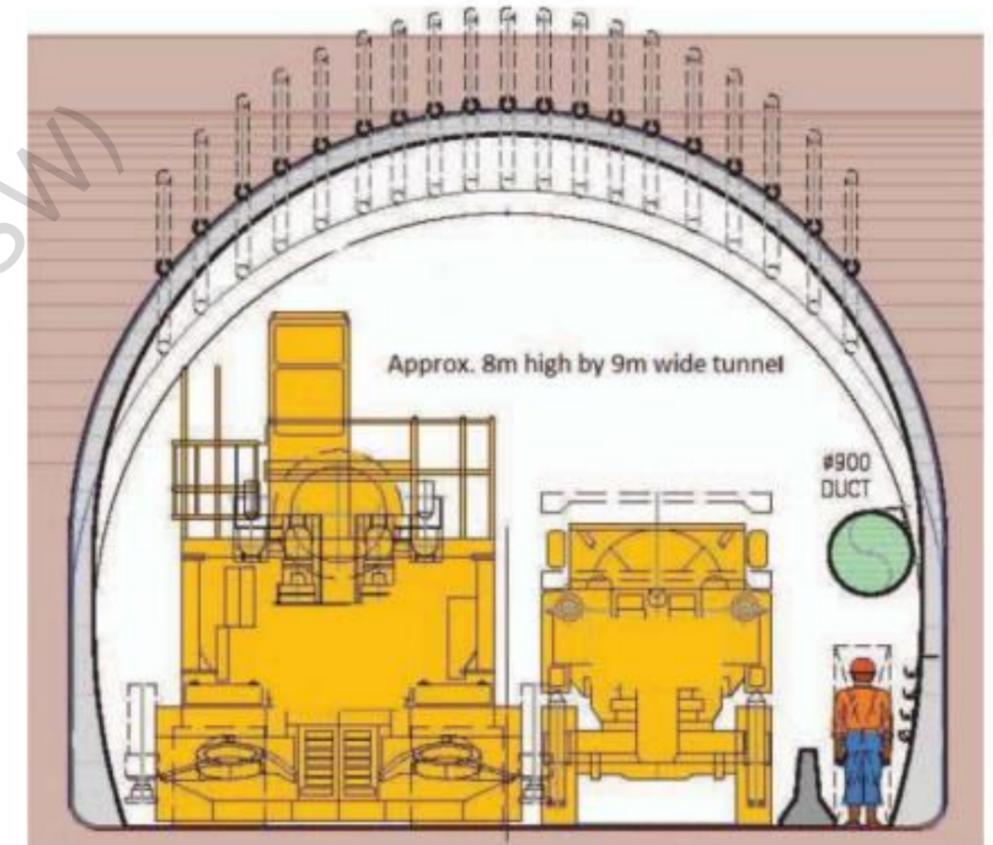
- Geotechnical investigations during track possession regime.
- Excavation cycle - Canopy tube, road header excavation, shotcrete lining.
- Synthetic fibre reinforced shotcrete without steel sets or lattice girders.
- 24-7 monitoring of rail for settlement

Outcomes

- ~6 month tunnelling period
- Limited disruption to rail operations
- Construction adjacent to and under live rail.

Considerations for a pedestrian tunnel at RNE

- Safety and security. Due to length, the end of the tunnel may not be visible.
- Footprint for dive sites are not available due to access constraints, heritage
- Interface with existing tunnels or dive structures
- Depth of tunnel and downward ramps



Tunnel Option

This section provides a high level description regarding the potential of a pedestrian connection below the rail corridor in lieu of a bridge crossing.

Consistent with the assessment undertaken for a potential new bridge crossing, the time benefit for crossing between north and south Eveleigh at this location in place of the new station crossing is minimal, being less than 3 minutes.



Existing Underground Structures

-  Study alignment below rail corridor as per preferred bridge alignment (tunnel invert 12 to 15m below existing track level)
-  DDA ramp length as radius (1 in 20 grade with landings) extending from tunnel invert
-  Illawarra Dive
-  Illawarra Tunnels (invert max 8m below existing track level)
-  Eveleigh maintenance tunnel
-  Pedestrian crossings
-  Eveleigh Maintenance Centre
-  Heritage



DDA Ramp Length:
 North: approx. 250m
 (or approx. 350m if it emerges north of Wilson Street)
 South: approx. 200m
 Ramps will need turns if they are to be located inside the site boundaries

The substantial level difference means that any ramps will be very long.

Therefore Lifts and stairs will be required at tunnel entries.

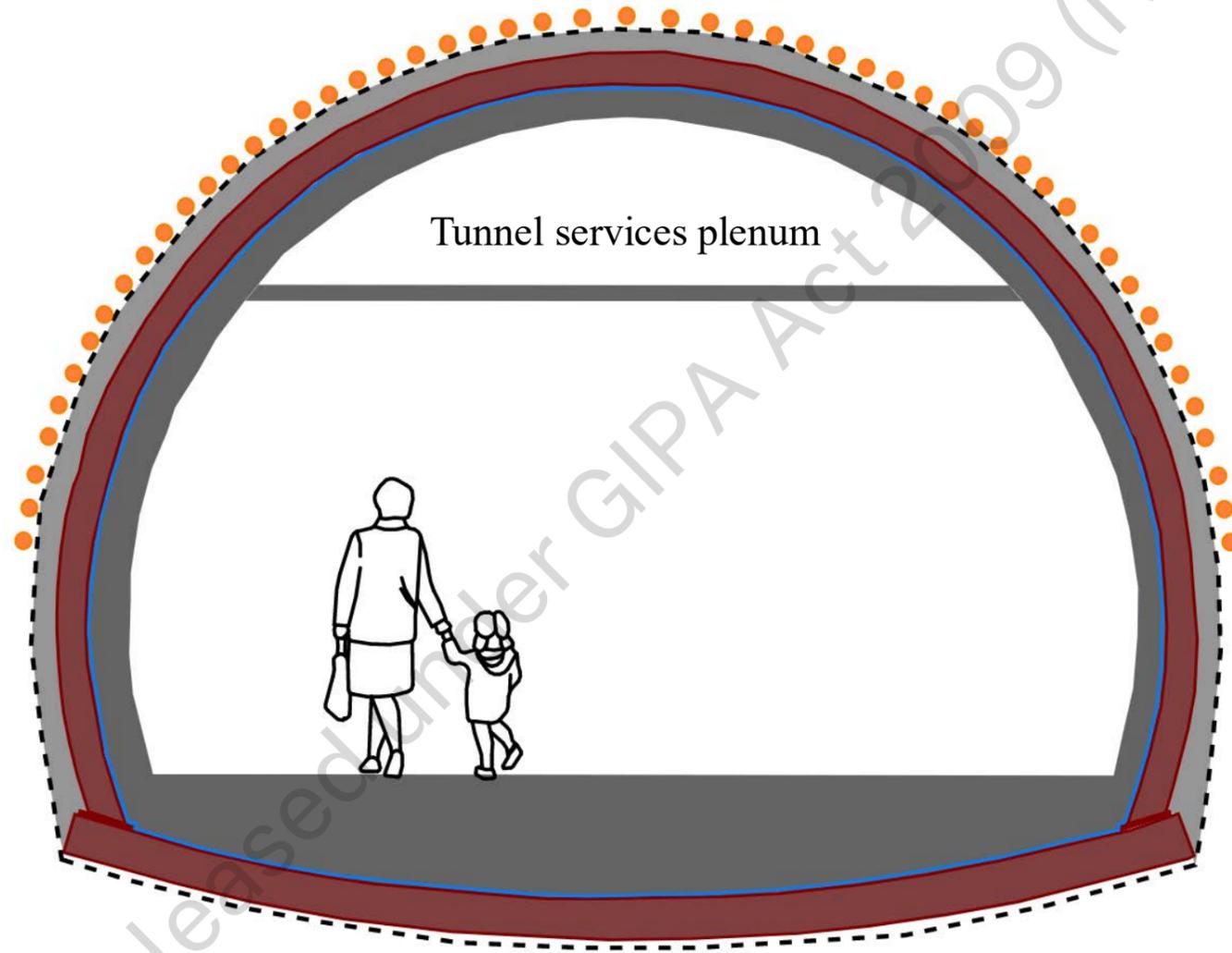
There are limited to no locations to stage/launch tunnelling works

Tunnel Typology

A progressively mined tunnel constructed using a traditional two pass support system (i.e. temporary support followed by permanent support) is considered to be the most appropriate tunnel typology for the anticipated subsurface ground profile and site constraints. The tunnelling methodology is similar to the case study presented earlier

Tunnel Support

- - Excavation profile – achieved using small road header or excavator
- Spiles/canopy tube pre-support
- Primary shotcrete lining
- Temporary steel sets
- Waterproofing
- Permanent cast in situ lining



Tunnel Overview

- Limit tunnel to 5m high x 4m width. This size is based on dimensions adopted for previous pedestrian tunnels in Sydney.
- Able to achieve 2.5m ground cover to existing structures and running rail



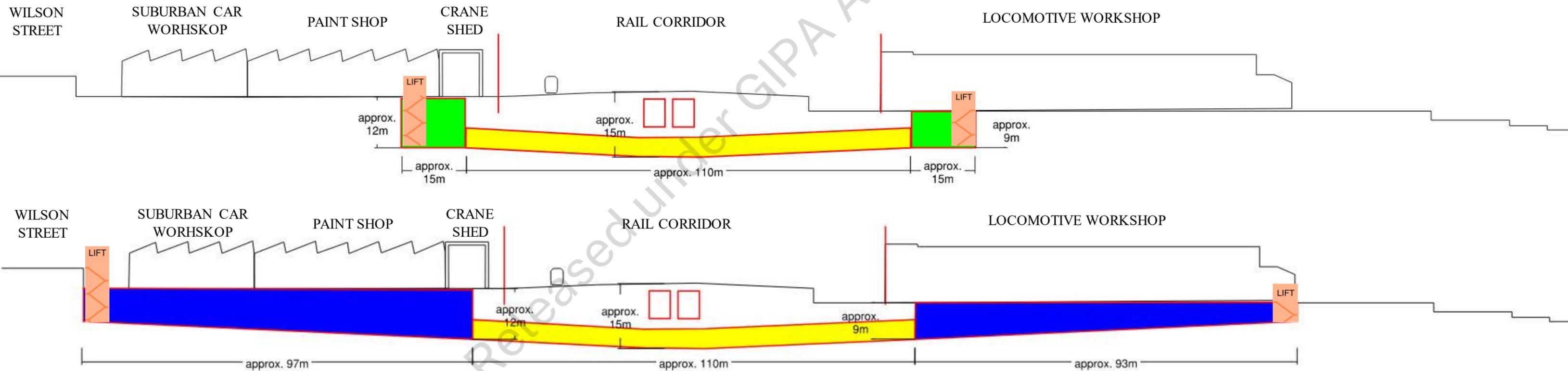
Image from the Arncliffe Pedestrian underpass, completed 2.5m below running rail

Tunnel Vertical Alignment

Due to the presence of the existing Illawarra tunnels a pedestrian underpass will need to be located below these tunnels with sufficient cover to minimise impact due to tunnelling. This would result in tunnel portals being 10-12m below existing surface levels at the northern (approx 3.5 storeys and 50 steps/risers) and southern northern (approx 4 storeys and 60 steps/risers) extents. The deepest point of the tunnel will be approximately 15m below the rail corridor in order to maintain a DDA compliant alignment.

Dive structures, or access shafts, will be required to provide access to the tunnel portal. Typically these can be achieved by traditional cut and cover methodologies, formed with bored contiguous or secant piled wall with a capping beam near ground surface, temporarily propped during construction, then reinstated with a plank roof at ground surface. *Note that the dives shown below are technically possible to construct, however are not practical and not available for construction due to heritage constraints and stakeholder requirements (ie. Maintenance facility cannot be interrupted as part of the operation of the rail network)*

- Existing Illawarra tunnels
- Mined tunnel – approximate length 110 m
- Cut and cover dive structures
 North dive – approx. length 97m
 South dive – approx. length 93m
- Cut and cover access shaft – approximately 15m square



Northern end:
 The traverser alignment implicates that a shaft, not a dive structure, is required. There may be an opportunity to coordinate the tunnel entry with the proposed Paintshop development. Stairs and lifts are required for both dive and shaft access.

Southern end:
 Entry via dive shaft, or longer mined tunnel and access shaft. There may be an opportunity at the southern extent to incorporate the dive structure/access shaft with adjacent developments (e.g. LES). Ensuring access to the maintenance facility will be a major constraint. Stairs and lifts are required for both dive and shaft access.

Design and Construction Considerations

Design

In addition to the tunnel temporary and permanent support, the following elements will need to be considered as a minimum:

- Tunnel ventilation
- Lighting (higher requirements than a bridge)
- Fire suppression
- Flooding ingress potential (including pumped drainage)
- Crime Prevention Through Environmental Design (CPTED)
- CCTV
- Associated power requirements
- Maintenance requirements (e.g. cleaning)

Fire design and emergency egress points will need to be considered (including consultation with Fire and Rescue NSW) as there may be additional requirements due to the overall length of the tunnel and dive structures.

Real time monitoring of the running rail, at surface and within tunnels will be required, full instrumentation and monitoring plan to be co-ordinated and approved by Sydney Trains.

Construction

Constructing a tunnel below live rail corridor will be difficult, however can be achieved provided sufficient resources are dedicated to it.

The benefit of tunnelling across the corridor is that the construction program can be decoupled from Sydney train movements and track possessions. Interfacing with Sydney Trains during construction will be limited to survey monitoring during tunnelling.

However it is likely that the tunnel crown will be formed within soil, and this will reduce the overall production rate for tunnelling. It is anticipated that excavation of the tunnel will be limited to a maximum of 1m full face advances. This will need to be incorporated into construction programs appropriately.

The dive structures will involve a greater impact to the existing tenants and structure at the northern and southern entrance structures. *In practicality, the area required for the dive structures are not available for construction.*

Design and Construction Considerations

Risks

- Ground conditions along the alignment are unknown. It is likely that the tunnel crown will be formed within soil or fill, specifically over the southern extent.
- Risk of contaminated material being encountered is very high based on previous experience within rail corridors and existing investigations within the Carriageworks, Clothing store, Paintshop and ATP precincts
- A number of existing buried utilities will need to be identified, rerouted, and co-ordinated.
- Coordination with neighbouring Stakeholders and Landowners is required for construction access.
- Approval from existing Stakeholders on the north side would be required for permanent access entry and exit points.
- Approval from existing Stakeholders and Land owners on the southern side would be required for permanent access entry and exit points, noting this.
- Significant constraints due to heritage listed structures requiring detailed assessment and approvals.
- Significant constraints due to the operational requirements associated with use of building (LES and Locomotive) on the southern side in a manner which allows for the current planned usage.
- Significant constraints due to the operational requirements associated with Carriageworks who service the building from the Traverser area.
- Significant long term disruption to the maintenance facility on the southern side is not likely to be acceptable due to the critical part this place to the rail network.
- Temporary diversions or access alternative will be required to achieve dive structures. Due to the heritage and stakeholder operational constraints (ie. Maintenances building and LES building), temporary diversions are unlikely to be acceptable, reducing the feasibility of a tunnelling option.
- There are no unrestricted areas available at ground level to stage and launch tunnelling construction works, increasing the complexity and reducing the feasibility of the tunnel option.
- Consideration and co-ordination would be required with planned redevelopment of the Paintshop sub-precinct which is likely to further increase the complexity of the tunnel option.