Appendices

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Cox Richardson

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ARCHITECTURE
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INTERIOR DESIGN

REDFERN STATION REDEVELOPMENT PROJECT

Peer Review of Previous Options C, D + E

REVISION 1 – 3 March 2009

CONTENTS

Document Control

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Draft	*05 Feb 2009*	*N Tyrrell*	*I McGilvray*
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1.0 INTRODUCTION

It is vital for Sydney as a city to accommodate growth in office space, accommodation, research and education, and the areas serviced by Redfern Station include significant government and private lands with the potential for much higher density. This area can be viewed as the southern extension of the CBD, and the redevelopment of Redfern Station can be seen as a catalyst for unlocking this growth potential and broader enhancement of the public realm.

Redfern Station is one of the oldest and most integrated in the Sydney rail network. Raising levels of equitable access, fire egress, station operations and commuter experience will provide public transport infrastructure appropriate for the 21st century.

This report provides a peer review commentary by Cox Richardson Architects and Planners of the previous design for the Redfern Station Redevelopment by Jackson Teece and Connell Wagner, referred to as Options C, D and E.

Relevant documents referred to in this report include the following:

- Redfern Station Upgrade - Concept Design Study - Part A - Urban Design Report April 2007 prepared by Jackson Teece and Connell Wagner (UDR 2007).
- Redfern Station Upgrade - Concept Design study - Part B - Engineering Report April 2007 prepared by Jackson Teece and Connell Wagner (ER 2007).
- Redfern Waterloo Built Environment Plan (Stage One) August 2006 prepared by the Redfern Waterloo Authority (BEP 2006).
- North Eveleigh Concept Plan March 2008 prepared by Urbis (NECP 2008).

This high level review explores the advantages and disadvantages of the different options in the context of function station operations, customer experience and broader public benefit. These issues are generally grouped into the following areas:

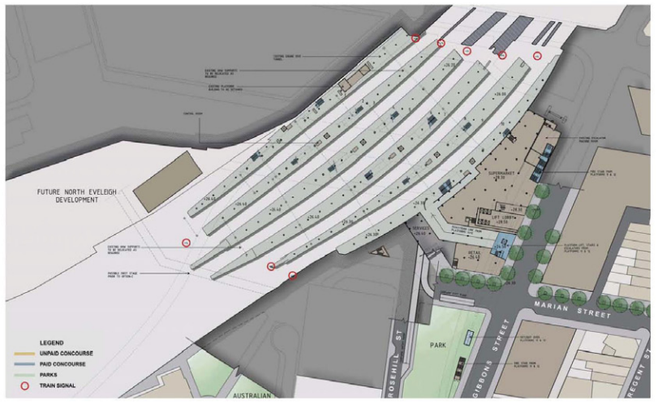
- Paid Concourse
- Connectivity and unpaid concourse
- Public domain
- Heritage
- Commercial development

We understand that cost of options C, D and E has been assessed at $319M, $29.5M and $208.3M respectively (refer UDR 2007 pages 21, 29, & 31) and that none of the options to date is seen as meeting all objectives of all stakeholders. Therefore the intent of the review is to identify positive aspects and possible avenues for further exploration.

This report should be read in conjunction with the appended Accessibility Review by Morris Godding & Associates and the Engineering Peer Reviewed by Arup.

2.0 PEER REVIEW ASSESSMENT

2.1 OPTION C



2.1.1 PAID CONCOURSE

This design incorporates a diagonal concourse alignment parallel to Lawson Street. We note that this arrangement is approximately 25% longer than the perpendicular arrangement suggested in a range of earlier options by Jackson Teece including Options B (refer to UDR page 90). It is possible that Option C better resolves existing constraints or other issues, however this remains unclear and in our option a perpendicular alignment warrants further exploration.

Potential advantages of the diagonal arrangement could include:

- Closer alignment with the centre of platforms below to achieve 3rd point loadings, although it is noted that the two edge platforms (1 and 10) have the smallest amount of traffic so perfectly centralised vertical connections on these platform may not be such an important factor.

- Alignment with the adjacent street grid beyond is indicated in the Redfern Waterloo Built Environment Plan (refer to BEP 2006 page 68). This creates a visual alignment, although this alignment is unlikely to be recognisable from street level. It also provides a direct pedestrian connection to the termination of Redfern Street which provides local retail amenity. However we note that Redfern Street and the area east of Regent Street is not the current or proposed employment focus and may not be one of the major destinations for commuters. We suggest that other options that achieve access to Redfern Street without necessarily aligning directly could be explored.

Potential disadvantages of the diagonal arrangement could include:

- The diagonal concourse is approximately 25% longer than a concourse perpendicular to the tracks. In addition to increasing material requirements and capital cost, this also increases the construction time and complexity given the concourse construction is above operating rail track. The impact of this on constructability requires review.

- The alignment clashes with the existing overhead wired structures requiring replacement of these structures over the majority of the station. In our opinion the existing OHW support structures are crudely detailed in comparison to recent station upgrades such as Chatswood. The existing structures create a significant negative visual impact and may ideally be replaced or modified. However the cost and construction issues in relation to such an amendment are significant and the environmental impact of replacing a functional structure purely for aesthetic reasons also needs to be taken into account.

- Transfer distance and travel times between platforms are increased proportionally although this may not be significant.

Option C incorporates significant changes to accessibility in the station that achieves a reasonable outcome as discussed in the appended Access Report.

The concourse is a simple legible space with good sightlines to platform access points. The width of the concourse required for pedestrian movement should be reviewed.

2.1.2 CONNECTIVITY AND THE UNPAID CONCOURSE

The area of unpaid concourse is significant and comprises a new or existing concourse connecting to Marian Street/ATP, and a pedestrian bridge linking across notionally to the North Eveleigh Precinct. This in effect creates three bridges (one paid and two unpaid) over the platforms. In attempting to equally connect to Redfern Street and ATP to the south, circulation paths become complex and as a result there is no one clear address point to the east. Travel times to and from key destinations should be assessed.

Potential advantages of the Option C unpaid concourse arrangement could include:

- A large extent of retail frontage and exposure.
- Connection to a public plaza adjacent to the termination of Redfern Street.
- Maintaining the traditional rail function of the station building on Lawson St.
- A separate pedestrian bridge over the platforms capitalises on the potential for shorter structural spans in comparison to a separate proposal for a free spanning bridge further south.

Potential disadvantages of the Option C unpaid concourse arrangement could include:

- The circuitous retail malls on the eastern side result in a lack of clarity and legibility of the station address. This undesirable outcome would be similar to the existing situation at Wynyard Station.

Wynyard has a multitude of below ground retail mall connections that are outside Railcorp control, and there are no direct sightlines to the paid concourse from the public domain.
- A lack of clarity and legibility for pedestrian travel generally.
- Significant capital cost due to large extent.
- Significant maintenance cost due to large extent.
- Significant area to provide security over.
- Retention of address point at Lawson Street perpetuates: congestion along the narrow footpath; poor public and consumer amenity; a perception of poor quality; and safety issues.
- A separate pedestrian bridge over the platforms increases the amount of column structures required to cope with collision loads and increases the extent of platform areas required to be constructed directly above operating rail lines.
- The connection from the bridge into North Eveleigh is not indicated, however this would either need to involve demolition of the existing heritage listed Telecommunications Equipment Centre (which would be inconsistent with the North Eveleigh Concept Plan) in order to make a direct connection, or incorporate a significant extent of elevated walkway around the building.
- Signalling is effected by the new pedestrian bridge and requires reconfiguration with additional cost and complexity.

2.1.3 PUBLIC DOMAIN

The new plaza space on Gibbons Street responds to the Built Environment Plan (BEP 2006 page 69) creating an open space at the termination of Redfern Street. However this space is a constrained transitional area connecting to the station. In terms of scale it provides limited potential as an important civic space and limited potential to increased public benefit. The BEP confirms our observation that the existing Lawson Square is "windswept and empty" (BEP 2006 page 64) and suggest a wind analysis of the proposed plaza be undertaken.

The design assumes closure of Marion St/Cornwallis St corner. A traffic assessment of the impact of this change would be required if this has not been carried out to date. A reduction in vehicular traffic at this corner may make pedestrian movement easier, but may also reduce passive surveillance resulting in public safety issues.

Option C does not convincingly achieve the following land use and design concepts as described in the Built Environmental Plan (refer BEP 2006 page 65):

- "Attractive functional civic spaces".
- "Transform the site to emulate its status as the southern gateway to the Sydney CBD".
- "Create a new town centre at the Redfern Railway Station, Gibbons and Regent Streets site to provide a vibrant focal point for Redfern".
- "Upgrade the Railway Station to improve the entrance".

The design does achieve good active frontages to the majority of the public domain resulting in high levels of passive surveillance and consequent public safety. The key area that is less successful in this regard is the Lawson Street Bridge. Its current high brick walls, narrow footpaths and barrier fencing combine to create an undesirable public domain. There is a sense that few would see what went on, and there is little opportunity to escape danger.

2.1.4 HERITAGE

As acknowledged in the Urban Design Report this option results in significant heritage impact (refer UDR 2007 page 17). Only the booking office on Lawson Street station building and ventilation stacks on Platform 1 are retained. Other structures on Platform 1 that are on the State Register are removed. Platform buildings on the other platforms that are the local heritage register are on removed. Potential advantages of removing this extent of heritage include:

- Removal of constraints.
- Creation of a new modern facility.
- Improved sightlines and spaces on the platforms.

Potential disadvantages of removing this extent of heritage include:

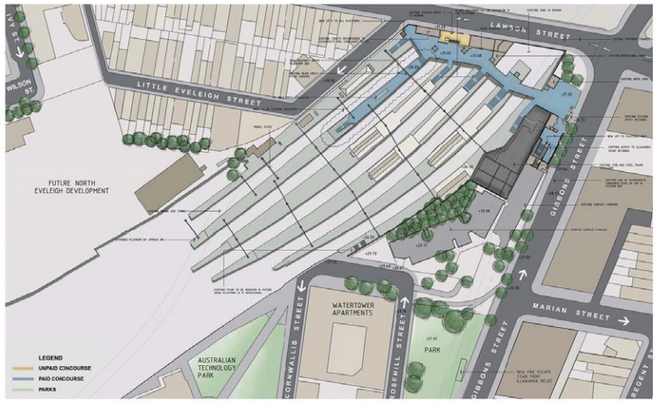
- Removal of part of the history and character that makes Redfern Station significant.
- Entirely inconsistent with the recommendations of the heritage report.
- Additional cost and construction complexity.

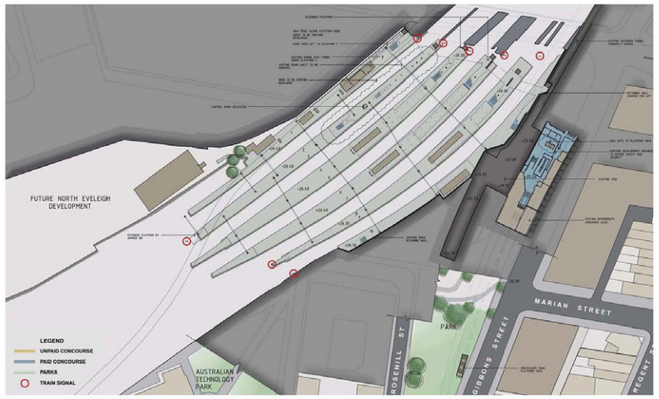
2.1.5 COMMERCIAL DEVELOPMENT

As noted above the design generates substantial retail areas that successfully provide active frontages to the public domain. However the design generates the following undesirable outcomes:

- Retail space that obstructs visual links to the station entrances.
- Convoluted retail malls.
- A supermarket below ground with limited, if any, potential for services access.
- A triangular shaped tower floor plate that is not a preferable commercial outcome and therefore inappropriate as a flexible masterplan envelope.

2.2 OPTION D





2.2.1 PAID CONCOURSE

The existing paid concourse at the north end of the station is essentially retained with minor modification above Platforms 8/9 to provide lift access. An additional walkway above Platforms 2/3 positions the access stairs more centrally and with increased side clearances and other stairways are retained in similar positions but modified to varying degrees.

Platform 4/5 has no clear view from the lift to centre of platform which is bad for safety and way finding.

As acknowledged in the Urban Design Report (refer UDR pages 27) and appended Access Review, this does not achieve equitable access to all areas or meet the intent of the DDA. Use of lifts is not encouraged as they are all located at the north end, requiring long travel distances for arriving passengers with mobility impairment.

The entrance down to the Eastern Suburbs Line platform is retained in its current remote position, resulting in poor integration and way finding. Platform cross falls not resolved.

Potential advantages of the Option D arrangement could include:

- Relatively inexpensive.
- No clashes with existing overhead wire structures.
- Reasonably compact concourse area minimizes maintenance and security requirements.

Potential disadvantages of the Option D arrangement could include:

- Minimal perceived improvement over the existing station.
- New blade columns on Platforms 6/7 and 8/9 create physical and sightline barriers for lift users.
- Signalling is effected and requires configuration.

2.2.2 CONNECTIVITY AND THE UNPAID CONCOURSE

This option does not provide any new public unpaid east/west connection.

Retention of address point at Lawson Street perpetuates: congestion along the narrow footpath; poor public and customer amenity; a perception of poor quality and safety issues. Entry from Lawson St does not meet DSAPT requirements.

The existing congested station entrance at Gibbons St is retained.

2.2.3 PUBLIC DOMAIN

There is no enhancement of the public domain, no increase in support facilities or active frontages overlooking the public domain.

Option D does not achieve any of the urban outcomes described in the 2006 Built Environment Plan (refer BEP 2006 page 65):

- "Attractive functional civic spaces".
- "Transform the site to emulate its status as the southern gateway to the Sydney CBD".
- Create a new town centre at the "Redfern Railway Station", Gibbons and Regent Streets site to provide a vibrant focal point for Redfern".
- "Upgrade the Railway Station to improve the entrance".

There is no improvement to the Lawson Street Bridge, with its high bricks walls, narrow footpaths and barrier fencing combine to create an undesirable public domain. There is a sense that few would see what went on, and there is little opportunity to escape danger.

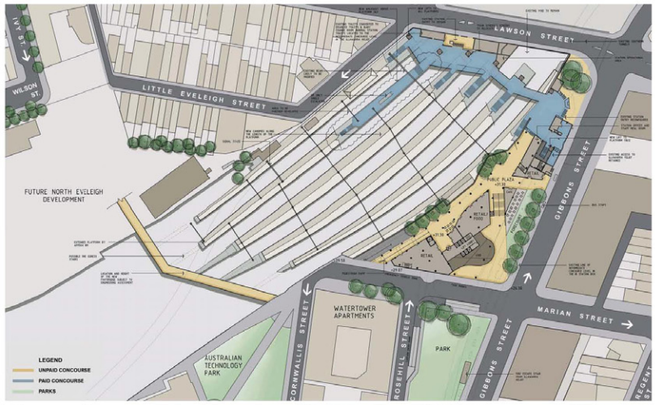
2.2.4 HERITAGE

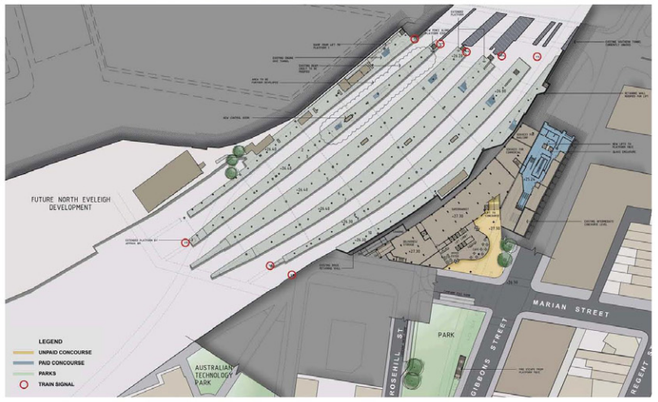
All the heritage items within the station have been retained.

2.2.5 COMMERCIAL DEVELOPMENT

No additional commercial space is proposed in Option D.

2.3 OPTION E





2.3.1 PAID CONCOURSE

The extension paid concourse at the northern end of the station is retained in position and expanded in width and is consequently more generous than Option D. In addition there are minor modifications above Platforms 8/9 to provide lift access. An additional walkway above Platforms 2/3 positions the access stairs more centrally and with increased side clearances and other stairways are retained in similar positions but modified to varying degrees.

As acknowledge in the Urban Design Report this does not achieve equitable access to all areas and may not meet the intent of DDA. Use of lifts is not encouraged as they are located at the north end, requiring long travel distances for arriving passengers with mobility impairment.

The entrance down to the Eastern Suburbs Line platform is retained in its current remote position, resulting in poor integrated and way finding.

Potential advantages of the Option E arrangement could include:

- Relatively inexpensive.
- No clashes with the existing overhead wire structures.

- Improved capacity in comparison to Option D.
- Reasonably compact concourse are minimises maintenance and security requirements.

Potential disadvantages of the Option D arrangement could include:

- Minimal perceived improvement over the existing station.
- New blade columns on Platforms 6/7 and 8/9 create physical and sightline barriers for lift users.
- Signaling is effected and requires reconfiguration.

2.3.2 CONNECTIVITY AND THE UNPAID CONCOURSE

This option assumes a separate new public pedestrian/cycle connection between the east and west sides of the rail lines to be located further south.

Retention of address point at Lawson Street perpetuates: congestion along the narrow footpath; poor public and consumer amenity; a perception of poor quality and safety issues. Entry from Lawson St-does not meet DSAPT requirements.

The station entrance at Gibbons St is retained in its general position and modified to slightly increase external forecourt space. This entrance also then connects to an adjacent retail mall and commercial development.

2.3.3 PUBLIC DOMAIN

There is some enhancement of the public domain with a minor increase in the size of the forecourt at the Gibbons St entrance, and a confused series of public plaza spaces/retail malls further south. This southern development has recesses and concealed spaces that may generate safety issues and are of little public benefit.

Option E does not archive any of the urban design outcomes described in the 2006 Built Environmental Plan (refer BEP 2006 page 65):

- "Attractive functional civic spaces".
- "Transform the site to emulate its status as the southern gateway to the Sydney CBD".
- "Create a new town centre at the Redfern Railway Station, Gibbons and Regent Streets site to provide a vibrant focal point for Redfern".
- "Upgrading the Railway Station to improve the entrance".

There is no improvement to the Lawson Street Bridge, with its high brick walls, narrow footpaths and barrier fencing combining to create an undesirable public domain. There is a sense that few would see what went on, and there is little opportunity to escape danger.

2.3.4 HERITAGE

This option does impact on existing heritage. While the booking office on Lawson Street and all stage register elements on Platform 1 are retained, the building on the other platforms that are on the local heritage register are removed.

Potential advantages of removing this extent of heritage include:

- Removal of constraints.
- Creation of a new modern facility.
- Improved sightlines and space on the platforms.

Potential disadvantage of removing this extent of heritage include:

- Removal of part of the history and character that makes Redfern Station significant.
- Somewhat inconsistent with the recommendations of the Heritage Report.
- Additional cost and constraints complexity.

2.3.5 COMMERCIAL DEVELOPMENT

As noted above the design generates substantial retail areas that successfully provide active frontages to Gibbons and a Marian Streets. However the design generates the following undesirable outcomes:

- Retail space with only low levels of pedestrian traffic that may mean it is of low quality or even unviable.
- Convoluted retail malls.
- A supermarket below ground with limited, if any, potential for services access.
- A triangular shaped tower floor plate that is not a preferable commercial outcome and therefore inappropriate as a flexible master plan envelope.

3.0 CONCLUSION

We concur with previous assessments that in principle Option C is a preferable outcome over both options D and E. We understand that the construction cost of the three options has been assessed and that option c is viewed as too expensive in its current form.

However, as noted in our assessment, we are of the view that there are opportunities for improvement to Option C that may not only reduce cost but also provide a superior outcome in terms of urban design, station address, legibility, heritage impact, the unpaid east/west linkage and the quality and viability of the commercial development on Gibbons Street.

REVIEW CRITERIA	OPTION C	OPTION D	OPTION E
Urban Design (Refer 2.1.3, 2.2.3 & 2.3.3)	Average	Poor	Poor
Visible Station Entrance (Refer 2.1.2, 2.2.2 & 2.3.2)	Poor	Average	Average
Clarity of Station Planning (refer 2.1.1, 2.2.1 & 2 .3.1)	Good	Poor	Poor
Sight Lines/Legibility (refer 2.1.1, 2.2.1 & 2.3.1)	Average	Poor	Poor
Equitable Access (Refer appended Accessibility Report)	Good	Unacceptable	Unacceptable
Passenger Amenity-Comfort-Security (Refer 2.1.3, 2.2.3 & 2.3.3)	Good	Poor	Poor
Travel Distance from Key Destination (Refer 2.1.2, 2.2.2 & 2.3.2)	Good	Average	Average
Heritage Impact Refer 2.1.4, 2.2.4, & 2.3.4	Poor	Good	Good
Provisional Unpaid Link Across Tracks (Refer 2.1.3, 2.2.3 & 2.3.3)	Average	Unacceptable	Poor
Quality Development Around Station (Refer 2.1.5, 2.2.5 & 2.3.5)	Poor	Unacceptable	Poor
Value for Money (Extrapolated from above)	Average	Poor	Poor

The potential areas of improvement that could be explored include:

OPTION C

Key Issues

- The diagonal concourse configuration results in a large amount of OHW gantry amendments.
- Longer than a concourse perpendicular to the tracks.
- In effect 2 separate bridges - paid and unpaid, hence expensive and disruptive.
- Poor urban design at eastern entry to concourse and bridge, poor legibility & way finding.
- Unresolved at western connection to little Eveleigh Street.
- No resolution of fire egress at end of platforms.

- Cost of removing most heritage structures.

Potential improvements

- Explore concourse perpendicular to tracks.
- Explore combining paid concourse and unpaid bridge in one structure.
- Improve Gibbons Street development urban design.
- Explore means of retaining Lawson Street and stairs for fire egress.
- Improve connectivity at western end to Little Eveleigh Street and a station entrance on this western side.

OPTION D

Key Issues

- Fails to provide equitable access for people with disabilities due to end lift position.
- Arguably does not meet the intent of DDA.
- Fails to address overcrowding and safety concerns at Lawson Street entry.
- Very disruptive to customers during construction process.
- Entrance to Eastern Suburbs Line is remote.
- No unpaid connection between the east and west sides other than Lawson street, hence fails to fulfil BEP or RWA requirements.
- Does not achieve third point loading of platforms.
- Relatively expensive.
- Minimal perceived improvement over the existing stations.
- Not a solution that creates a southern gateway to Sydney.

Potential Improvements

- Explore raised walkway over platforms (similar to Platform 1/2) in order to relocate lifts towards platform centre to distribute VT along platforms.
- Explore opening up Lawson Street station entry building to relieve congestion on footpath.
- Relocate entrance to Eastern Suburbs Line closer to Gibbons Street entry.

OPTION E

Key Issues

- Provides unpaid bridge link from ATP to North Eveleigh (similar to Eveleigh Heritage walk proposal).
- Similar in other respects to Option D comments above.

Potential improvements

- Similar issues as per Options D above.

RECOMMENDATIONS

Our recommendation is to explore modifications to Option C that address the issues raised in this report and then carry out a comparative assessment of that design against the current Option C, using the criteria noted above.

COX RICHARDSON

REDFERN RAILWAY STATION

ACCESS REVIEW

Morris-Goding Accessibility Consulting

V4

5th March 2009

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1. INTRODUCTION

1.1. General

Cox Richardson has engaged Morris-Goding Accessibility Consulting, to provide a design review of 3 options of the proposed refurbishment of the Redfern Railway Station.

The requirements of the investigation are to:

- Review supplied drawings & descriptions of the proposed 3 design options.
- Provide a report that will analyse the provisions of disability design of the development, and
- Recommend solutions that will ensure the design complies with the Federal Disability Discrimination Act (DDA), Building Code of Australia (BCA) and AS 1428 series.

1.2. Objectives

The Access Review Report considers user groups, who include members of the public. The Report attempts to deliver equality, independence and functionality to people with disabilities.

The Report seeks to provide compliance with the DDA. In doing so, the Report attempts to eliminate, as far as possible, discrimination against persons on the ground of disability and ensure, as far as practicable, that persons with disabilities have the same rights to equality before the law as the rest of the community.

1.3. Statutory Requirements

The following standards are to be used to implement the Report:

- AS 1428.1 - (80% of people with disabilities accommodated)
- AS 1428.2 - (90% of people with disabilities accommodated)
- BCA - Building Code of Australia
- DDA Transport Standards

2. OPTION C - FULL STATION REDEVELOPMENT

2.1. Entrances

The proposed main entrance/exit to the Station is from the proposed public Plaza (Gibbons Street), which is stated as being accessible.

There is an accessible linkage from Gibbons Street to the Plaza. There appears to be suitable access via ramp to the Plaza from Marion Street. There is accessible linkage from the Plaza to the Station main entry and to the pedestrian bridge that connects with Station entry near Little Eveleigh Street.

It appears the accessible entry points have sufficient widths to allow 2 wheelchairs to pass each other in accordance with AS1428.2 and DDA Transport Standards.

There is also a pedestrian link between the buses on Gibbons Street to the Public Plaza. The Jackson Teece documentation states the pedestrian link is via 1:20 walkways (suitable), however this is not shown on the plans.

There is an issue of inequity for wheelchair users due to the placement of escalators on the path of travel from Gibbon Street to the Plaza. This is the most direct pathway from bus stop to station entry. A lift should be provided adjacent the escalators.

There is no mention of accessibility on the plans to North Eveleigh. It is important that an accessible connection to this precinct is provided.

2.2. Paths of Travel

In general, the main paths of travel within the concourse and plaza and in and around the entrances appear to be accessible with appropriate clear widths and circulation areas.

There appears to be continuous accessible paths of travel throughout the concourse to the passenger lifts that access platforms 1-10.

The drawings show that access to platforms 11-12 is via passenger lift that accesses platform 10; and a ramp that leads to another lift, which accesses platforms 11-12. Suitable way finding signage will be required.

There are two sets of stairs leading down to the platforms, adjacent the passenger lifts on platforms 1-10. These stairs will need to have appropriate handrails and tactile ground indicators in accordance with DDA Transport Standards.

According to the documentation, the existing shelter on platform 1 impacts on the accessible path of travel required for appropriate wheelchair use. This could be correct, however the drawings are not at a sufficient scale to analyse correctly.

All platforms will need to have crossfall gradient no steeper than 1:40.

2.3. Passenger Lifts

There is a passenger lift (6 in total) that accesses platforms 1, 2&3, 4&5, 6&7, 8&9 and 10. It is advised that these lifts need to be through car lifts, so wheelchair users can enter and exit in the same direction.

2.4. Sanitary Facilities

There is a public unisex accessible toilet on the new concourse area. The internal dimensions of the accessible toilet will need to comply with AS1428.2 and the DDA Transport Standards.

The Jackson Teece documentation states that there are also ambulant cubicles located in the new gender specific areas. This is suitable under DDA Transport Standards (DSAPT).

3. OPTIONS D & E

3.1. Entrance

The Lawson Street footpath does not provide an accessible path of travel to the concourse area due to the step at the entry. An accessible ramp would need to be provided.

There is suitable access from Gibbons Street to the concourse.

3.2. Paths of Travel

In general, the main paths of travel in and around the entrance area are continuous and have appropriate clear widths and circulation areas. There are continuous accessible paths of travel throughout the concourse to the passenger lifts and down to the platforms.

Each platform has lift access. However it is noted that the lifts are located at the ends of the platforms away from the length of the platform and will cause issues with the lack of functional wheelchair access with the pedestrian traffic at the stairs during peak flows. The sightlines are poor from the lift to the platform.

There are stairs leading down to the platforms, near the passenger lift. These stairs will need to have appropriate handrails and tactile ground indicators in accordance with the DDA Transport Standards.

The drawings do not show the bus stop/interchange and therefore the accessible path of travel between the bus stop and station entry is unknown.

All platforms will need to have crossfall gradient no steeper than 1:40.

Jackson Teece documentation states there is lift and ramp provision to access platform 1. The drawings do not show this arrangement. Further documentation is required to provide analysis.

Option E does show a bus stop along Gibbons Street that appears to have an accessible path of travel leading to the railway station concourse. It is noted that the gradients of this pathway are unknown.

Jackson Teece documentation also states that Option E has an east west link (southern end). This is not shown on the drawings.

3.3. Passenger Lifts

The lifts are small in width and will not allow people to turn with the lift car to be able to equitably exit the lift with dignity.

3.4. Sanitary Facilities

Mention has been made in the drawings that an accessible toilet will be provided in the existing toilet area to comply with DDA. The internal dimensions of the accessible toilet will need to comply with AS1428.2.

4. CONCLUSION

Options D & E have fundamental shortcomings with regards to equitable and dignified movement for wheelchair users.

(i) The lifts are located at the far ends of the platform and make the platforms difficult for people in wheelchairs to use.

(ii) Wheelchair users will need to back out of a lift to access either platform or concourse (a through lift would be required)

(iii) Sightlines are poor from lift to railway platform

(iv) These options have exposure to ramifications under the DDA.

The option design that would be considered the most appropriate for easy access would be option C for the following reasons:

(i) The access lifts will be located centrally for each platform. This means that travel distances are shorter and the ease of movement for wheelchair users is better.

(ii) There will be easy accessible connection to the North Eveleigh development

(iii) There will be better access and shorter distance between bus stop and station entry

RailCorp

Redfern Station

Peer Review & Data Review

RailCorp

Redfern Station

Peer Review & Data Review

March 2009

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Revision	Date				
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		Description	First draft		
			Prepared by	Checked by	Approved by
		Name	Lawrence Nassivera	Paul Stanley	Paul Stanley
		Signature			
Draft 2	05/02/09	Filename	001-C Peer Review Comments.doc		
		Description	Second draft – includes conclusions / checklist		
			Prepared by	Checked by	Approved by
		Name	Lawrence Nassivera	Paul Stanley	Paul Stanley
		Signature			
Issue	16/03/09	Filename	002 Redfern Peer Review Report Issue.doc		
		Description	Issue – addresses RailCorp comments		
			Prepared by	Checked by	Approved by
		Name	Lawrence Nassivera / Doug Pickering	Paul Stanley	Paul Stanley
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document Verification with Document ✓

Contents

Executive Summary

This report details Arup's pedestrian assessment of the Connell Wagner report *"Requirements for vertical circulation under peak normal AM loads Redfern Station Redevelopment – Revision F, 12 April 200, Reference 23443/0027"*.

In addition, Arup performed a review of the 2061 demand data and its implications to the current preferred design Option (Option C).

Our view of the Connell Wagner static analysis is that the general approach is reasonable to estimate the vertical transport (VT) performance. By undertaking a similar approach and methodology, Arup are comfortable that the key messages outlined in their executive summary are reasonable, i.e. that Option C provides the best vertical transport solution and that stair widths at 2031 are reasonable given volume, expected queuing and train frequency.

The key areas of concern are

- Connell Wagner's usage of stair flow rates
- Connell Wagner's approach to uplifting 2006 boarding/alighting data based on uplift factors from the Harbour Link Model (HLM)
- The lack of information regarding the distribution of stair usage (i.e. the impact of the placement of the Option C concourse)
- The lack of information and detail with respect to the origin and destination of passengers outside of the station. Any future design must understand peoples' final destination such that we can accurately estimate the impact of entry/exit points
- The lack of discussion regarding the performance of the concourse through analysis of key interchange movements (i.e. areas which are expected to have higher footfall, congestion than others).
- The lack of any discussion regarding the interface of the entry/exit points to the surrounding areas (i.e. can people actually connect to their final destination)
- The lack of any examination of the usage of different types of vertical transportation (e.g. a mix of stairs and escalators) and how the mix could aid operational management of the station
- The lack of any examination of the benefits/disbenefits of maintaining the existing part of the station for interchange movements

With respect to the STEPS modelling, Arup do not believe this is a suitable tool to test the performance of vertical transport for Redfern station. The bi-directional nature of flows on the stairs for city loop platforms would suggest a tool like Legion or Arup's own MassMotion – i.e. an emergent behavioural tool where the flow rate is determined by pedestrian flow and stair width rather than being an input to the model. As such, the STEPS model is only replicating the spreadsheet analysis and not providing anything new to the design team. In addition, there is no output information from the model to indicate performance of platforms (queuing areas), or the performance of the concourse (space utilisation metrics). As such, Arup believe the STEPS modelling to be of very limited value.

Finally, this report reviews the performance of Option C, D and E at 2031 and 2061.

1 Introduction

Arup has been engaged by RailCorp to progress the concept development planning of Redfern Station to the project definition stage, on the basis of work undertaken by Jackson Teece / Connell Wagner in 2007. The anticipated outcome of the design progression is a refined concept design that can be used as the basis for a business case submission by RailCorp for government funding.

This report is a peer review report undertaken at the commencement of the engagement, to review the concept design options C, D and E developed by Jackson Teece with respect to pedestrian movement and capacity. The pedestrian analysis review has concentrated on the following specific areas:

- **Executive Summary:** A review of the key conclusions of the previous pedestrian findings and any significant issues that are relevant to the current study and how these should be tackled.
- **General Approach:** A review of the Connell Wagner desktop-static approach and the benefits and risks associated with the conducted method.
- **Demand Data**: A review of the demand data used within the 2007 analysis and the usage of 2031 data. In addition, Arup also investigates the impact of 2061 demand data.
- **Assumptions:** Commentary on the underlying assumptions used and whether any of these assumptions are not valid or are no longer relevant to the current study.
- **Modelling:** Review of the STEPS modelling undertaken by Connell Wagner.

For each of these sections above, Arup have commented on the Connell Wagner analysis and outputs and provide a summary of actions/recommendations which should be raised during the Options Analysis stage of the project.

1.1 Peer Review Reference Documents

The primary document referenced as part of the pedestrian analysis review is the *"Requirements for vertical circulation under peak normal AM loads - Redfern Station Redevelopment – Revision F, 12 April 200, Reference 23443/0027"*.

Other documents referenced are as follows:

- Redfern Station Redevelopment Project - User Requirements (v1.2), March 2007
- Concept Design Study - Part A - Urban Design Report, Jackson Teece, April 2007
- Concept Design Study - Part B - Engineering Report, Connell Wagner, April 2007
- Requirements for vertical circulation under peak normal AM loads - Redfern Station Redevelopment – Revision F, 12 April 200, Reference 23443/0027

2 Pedestrian Analysis Review

2.1 Summary

In general, Arup agree with the main conclusions of the Executive Summary of the Connell Wagner vertical circulation report, as follows:

- The AM period is the critical period and more vertical transportation is the driving requirement for capacity improvement
- Stair performance should be measured by understanding platform clearance impacts, rather than the Level of Service (LoS) density measure for stairs stipulated by RailCorp's design guidelines
- Timetable frequency improvements are critical to the success of Redfern station.
- Option C provides a significant improvement to the current vertical transportation capacity.

2.2 Data & Assumptions

This section reviews the data and underlying assumptions that form the basis of the Connell Wagner pedestrian analysis. The majority of the assumptions used by Connell Wagner are reasonable, and in most cases the values used are conservative (e.g. escalators and gate line flow rates). However there are a number of key assumptions or data inputs which have not been considered or commented upon. These are:

- The external influences (destinations) of commuters to understand the impact of entry/exit locations
- An agreed performance criteria for vertical transportation. Arup agrees with Connell Wagner's assessment of Fruin LoS C for stairs that a measurement of stair density does not provide a suitable metric for measuring vertical transport performance. Arup believes the metric should relate to the impact of the stair capacity on network performance and as such, for the AM period, platform queuing / platform clearance is the key metric.
- Consideration of the impacts of simultaneous train arrivals.
- The assumptions regarding the distribution of passengers to each stair in Option C.

Recommendation: *With respect to external influences, there is very little value in undertaking a pedestrian survey while the University is closed in January / February. Instead we recommend using the data that Arup have analysed and is presented in section 2.2.1. If this data is unsuitable, alternative data or a survey in March will be required.*

Recommendation: *With respect to agreed vertical transportation performance metrics, we propose to use a maximum platform clearance of 90 seconds and average clearance of 60 seconds. For loop stations, the values of maximum and average should be set lower to reflect the importance of the capacity constraints of the loop e.g. for Town Hall, these were set at 45secs and 60secs respectively. Note, for P1, we recommend a maximum and average of 90 seconds (given the service frequency is assumed to be 7tph)*

2.2.1 Unpaid Data

The Connell Wagner report has focused on the suitability and performance of the vertical transportation elements of the station, and thus their approach to predominantly focus on paid movements is reasonable. However, the only reference to external station movements is provided in section 5.3 of their report and it is unclear a] how the percentages of east/west movements have been generated and b] what the likely shift of movements would be between now and 2031 and on to 2061. An understanding of external movements is important to understanding the likely shift in peoples' movements if changes in station entry/exit positions occur (i.e. as is the case in Option C). Thus understanding the percentages travelling to ATP, the University, North Everleigh etc. is very important to the analysis of the paid concourses and gatelines. This appears to be overlooked in the Connell Wagner report.

Recommendation: *Arup have reviewed the 2008 gateline data to test the current east/west splits against current landuse estimates provided by RWA for 8 key locations around the station. Arup have then used the future landuse estimates to predict the changes in movements at 2031 and 2061. The following charts indicate the percentages now and in the future. Arup recommends that these estimates are reviewed and agreed by RailCorp and/or RWA before further design analysis is undertaken.*

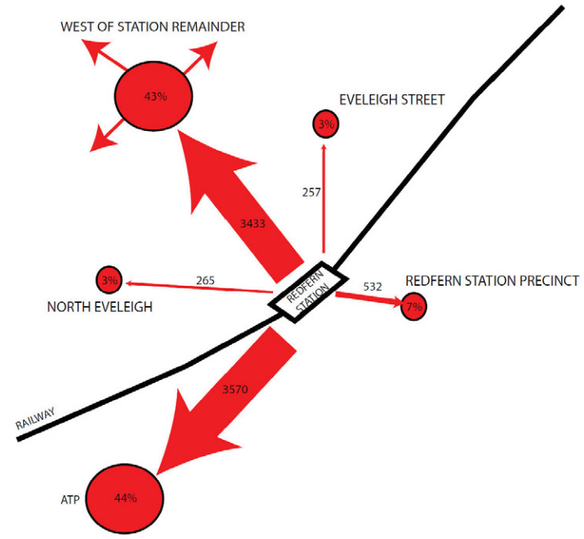

Figure 1: 2008 3.5hr Peak AM Demand and destination percentages

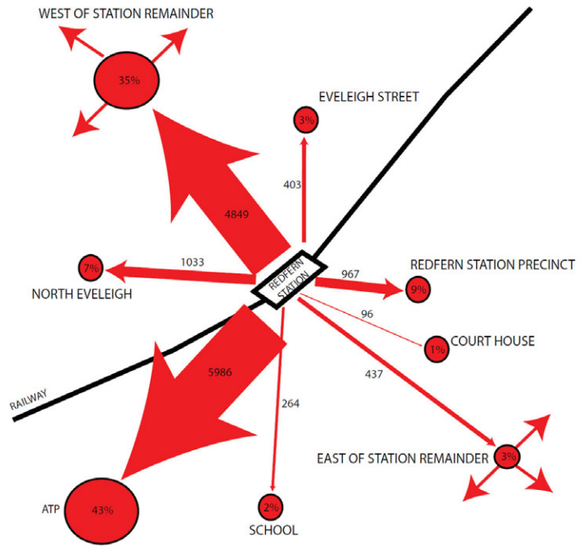

Figure 2: 2031 3.5hr Peak AM Demand and destination percentages

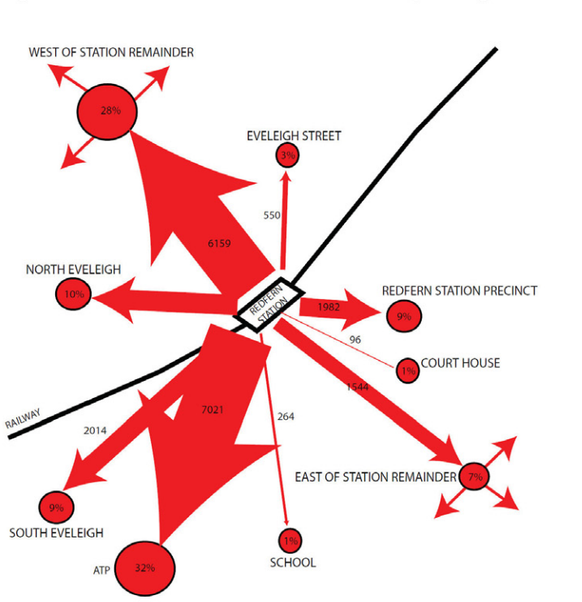

Figure 3: 2061 3.5hr Peak AM Demand and destination percentages

2.2.2 Paid Data

The Connell Wagner report has taken 2006 survey data to obtain maximum passenger boarding and alighting demand for each platform. The 2006 observed boarding and alighting figures have then been uplifted to 2031 based on the differences between 2006 Harbour Link Model (HLM) data and 2031 HLM data.

Arup's preferred approach is to take the 2031 numbers and break the volumes from 3.5 hours to peak 15 minutes using suitable factors and then apportion to trains based on the frequency inherent within the timetable. This reduces any risk of the 2006 observed figures having any variability/noise associated with the particular timetable run that day. However, in addition to this approach, we recommend considering a number of specific timetable / demand scenarios to test the behaviour of P1 arrivals and subsequent passenger boarding to P3, P5, and P7.

Recommendation: *Arup recommends using the recently provided HLM data for 2031 and 2061 as given below.*

2031-Emp-2-Trips.xls

Redfern	*Base 2031*		DepPla>								
ArrPla	1 (ICR2)	3 (SN)	4 (NS)	5 (CO1)	6 (CI2)	7 (CI1)	8 (CO2)	11 (SE)	12 (ES)	Exit	Total
1 (ICR1)		1,310	109	921	50	613	3	638	44	101	3,789
3 (SN)				62		312	50	128	509	4,125	5,186
4 (NS)	12						6			1,482	1,500
5 (CO1)	11		0				2	76	372	1,879	2,340
6 (CI2)										480	480
7 (CI1)	33	187	775		618		7	197		3,440	5,257
8 (CO2)			14						4	246	264
11 (SE)	10	634	722	526	589	781				3,240	6,502
12 (ES)	10		17		25		26			426	504
Entry	59	1,165	387	147	619	88	355	374	247		3,441
Total	135	3,296	2,024	1,656	1,901	1,794	449	1,413	1,176	15,419	29,263

Table 1: Revised 3.5hr AM Peak 2031 HLM data for Redfern station

2061-Emp-2 ECRL-Trips.xls

Redfern	*Base 2051*		DepPla>								
ArrPla	1 (ICR2)	3 (SN)	4 (NS)	5 (CO1)	6 (CI2)	7 (CI1)	8 (CO2)	11 (SE)	12 (ES)	Exit	Total
1 (ICR1)	0	1,988	391	1,432	56	960	4	986	54	160	6,030
3 (SN)	0	0	0	77	0	408	58	168	606	5,950	7,268
4 (NS)	20	0	0	0	0	0	7	0	0	1,938	1,965
5 (CO1)	17	0	0	0	0	0	3	103	465	2,585	3,174
6 (CI2)	0	0	0	0	0	0	0	0	0	708	708
7 (CI1)	54	227	906	0	722	0	8	239	0	5,336	7,491
8 (CO2)	2	0	15	0	0	0	0	0	4	355	377
11 (SE)	11	840	848	710	695	1,038	0	0	0	4,641	8,784
12 (ES)	12	0	19	0	28	0	26	0	0	607	692
Entry	59	1,408	497	209	751	124	474	474	315	0	4,312
Total	175	4,463	2,676	2,428	2,252	2,531	581	1,970	1,444	22,281	40,800

Table 2: 2061 3.5hr AM Peak 2061 HLM data for Redfern station

2.2.3 Other Assumptions

Assumption	Suitability	Recommendation
Stair Flow rate	There is some confusion within the report regarding stair flow rates and appropriate usage for the design process.	Arup recommends 50ppmm for stairs which experience predominantly unidirectional flow and 35ppmm for stairs that frequently experience bi-directional flow. Observations at Town Hall, Wynyard, Burwood and Newtown stations have consistently shown that passengers are able to obtain maximum peak per minute stair flows above 60 people/metre/minute with a sustained maximum of approximately 50 people per metre per minute for unidirectional flow. For a design study, London Underground would recommend 35pmm and 28pmm for uni and bi-directional flow respectively. MTR would recommend 63pmm and 50pmm for uni and bi-directional flow on the basis that research has shown the Asian population is more efficient in crowd behaviour than their European counterparts. Given no stipulated RailCorp guidelines, Arup recommend to us 50ppm uni-directional flow and 35ppm bi-directional flow. Hence for P1, which is predominantly unidirectional, a rate of 50ppm should be used to estimate stair widths. For P2/P3 which experiences considerably more bi-directional flow, a rate of 35ppm should be used.
Escalator flow rate of 80ppm	Conservative but reasonable	Escalator flow rates vary between 80-120ppm, but 90-100 can be sustained for short periods. In a commuter environment, we would recommend 100ppm as a design rate. RailCorp have indicated a preferred flow rate of 90ppm, which will be adopted for future analyses of Redfern Station.
Ticket Gate of 20ppm	Conservative	Recommend using 25ppm. A wider DDA gate should be included in case there are unpredicted surges.
Boarding and Alighting profiles	These will vary significantly on passengers' final destination, time of day, platform, and weather conditions.	We recommend analysing the VT based on the assumption that all commuters are able to access the VT element(s) within 1 minute.
2006 to 2031 uplifts	N/A	Use updated 2031 data as provided by HLM
2031 Station directional demand split as per section 5.3	This area is weak and we would have preferred to have seen more data with respect to final destinations. Without knowing movement patterns outside of the station it is difficult to determine their likely revised exit profiles for the proposed designs. There is no discussion in the change of movement patterns from 2006 to	We recommend using the data provided in Section 2.2.1

	2031. Gateline data would also have assisted here.	

Table 3: A review of the main assumptions used within the Connell Wagner pedestrian analysis

2.3 STEPS Modelling

A review of the STEPS reporting within "*Redfern Station Upgrade – Concept Design Study, Part B Engineering Report, April 2007*" has been undertaken. The key points to note are:

- Arup have not been given access to the STEPS model, so we are unable to comment about its construction, methodology and application of the inputs and subsequent outputs.
- STEPS is not an ideal tool for bi-directional flow on stairs. A more appropriate tool is Legion or Arup's own tool, MassMotion.
- STEPS takes stair flow rates as an input – rather than being emergent (i.e. what you put in is what you get out). As such, the simulation is only replicating the performance of the static analysis. Tools like Legion or MassMotion can predict the flow rate from stairs based on the geometry, the pedestrian volumes, and the impact of unidirectional and bi-directional negotiations.
- Some of the demand data within section 2.6 seems unreasonable. (e.g. P1 appears to have 4 services within the peak 15 minutes, whereas there are only 7 across the full peak hour).
- P5 has only 2 services in the peak 15 minutes yet is subject to a 20 trains per hour service frequency at 2031.
- There is no graphical output provided – nor discussion about the space utilisation of the concourse (one of the main benefits of undertaking a model of this kind)
- There is no discussion/analysis regarding the interface of the station entrance and the street – or the impact of the entrance location with respect to commuters' final destinations.

  Recommendation: *A MassMotion or Legion model of the key areas would be beneficial to the design team to understand movement patterns and congestion areas. It will also be useful as part of the cost benefit process / evaluation as part of the business plan.*

3 Options Analysis

3.1 Option Summary: Option C, D and E

The graph below shows the comparison of estimated platform clearance times at 2061. The chart demonstrates that key platforms are estimated to have a clearance times in excess of 90 seconds and that for Options D, E and existing, the clearances are above that of the headway of the train frequency on P2/P3, P4/P5 and P6/P7.

Option C has a high clearance time for P10 due to the nature of the access route to P11/P12. Option D/E performs better on P2/P3 given that more vertical transport is provided – however, there are concerns that the improvement of P2 will be offset by a worsening of other platforms based on this design. This is explored in later sections.

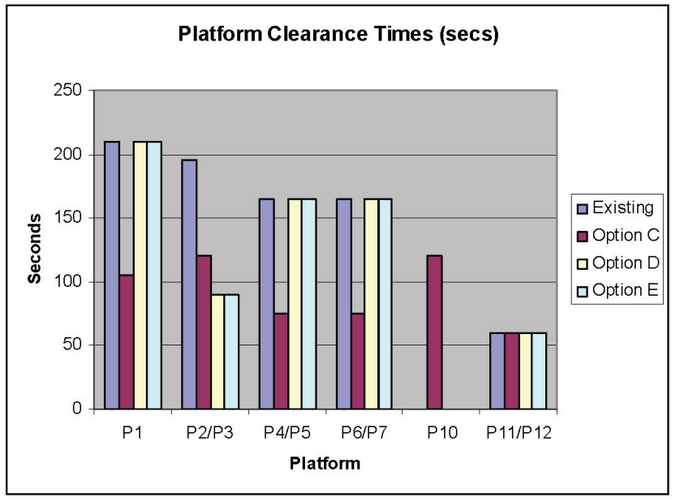

Figure 4: Maximum Queue (per stair) for Option C, D and E at 2061

3.2 Option C

Arup have conducted a comparative static analysis (which is labelled ARUP TEST) of Connell Wagner's Option C based on:

- Connell Wagner's provided 2031 data for alighting and boarding loads (pg 8, Section 3.3 last column)
- A assumed stair flow rate of 37 people per metre per minute
- Connell Wagner's Alighting and Boarding profile for Option C (pg 11, Section 3.5)
- The assumption of simultaneous train arrivals

In addition, Arup have conducted their own analysis (ARUP Preferred) based on:

- A stair flow rate of 35 people per metre per minute for all platforms except P1, where a flow rate of 50 people per metre per minute has been used

The following two graphs show the maximum queue and platform clearance time for each platform and compare the outputs from the Connell Wagner report, the Arup comparative test and the Arup preferred approach.

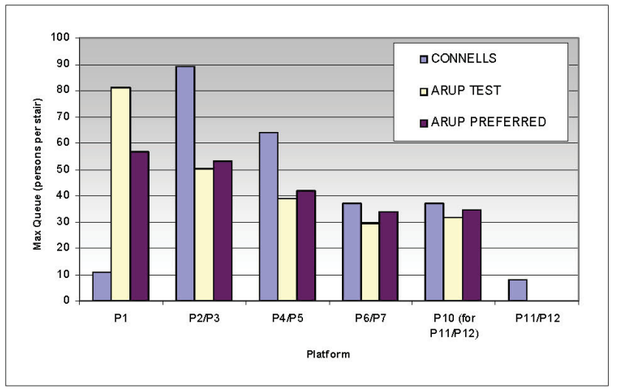

Figure 5: Maximum Queue (per stair) comparison for Option C at 2031

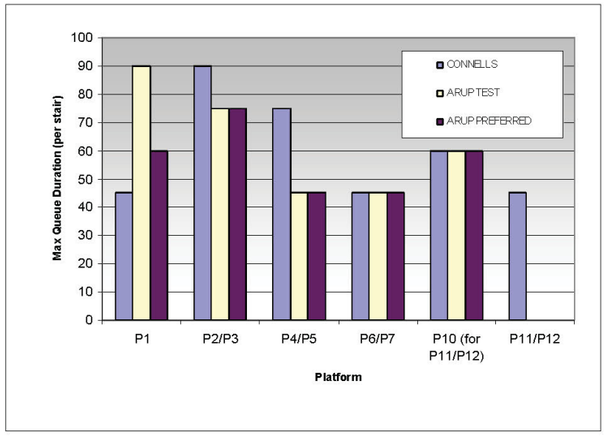

Figure 6: Maximum Queue Duration comparison for Option C at 2031

The results show that we have not been able to replicate the Connell Wagner analysis and without detailed discussion with Connell Wagner it is difficult to fully understand the differences. However, the significant differences that require further investigation are for Platform 1 and Platform 2/3. For P1, Connell Wagner is indicating a maximum queue of only 11 people from an alighting load of 340 people at 2031. Given a 5m stair which Connell Wagner has assumed a capacity of 185 per minute (5 * 37ppm), then we would expect at least 340-185 = 155 to still be queueing on the platform at the end of 1 minute, or 78 per stair.

For P2/P3, Connell's are predicting a maximum queue of 89 people, with a maximum duration of 90 seconds, whereas Arup are predicting a maximum queue of 50 per stair and with a clearance of 75 seconds. The difference may relate to whether Connell Wagner is reporting a maximum platform queue, rather than a stair queue. Further investigation is required.

Recommendation: *Arup disagrees with the analysis for P1 by Connell Wagner and recommends using the Arup results as presented within fig 5 and 6. A computer simulation model of the P1 scenario has been constructed and is shown below.*

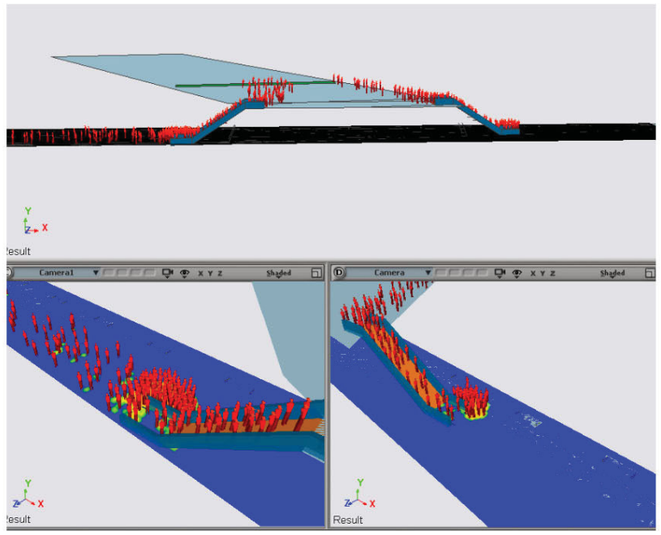

Figure 7: A MassMotion model showing queueing for a P1 alighting scenario

3.2.1 Option C - 2061

Using a similar approach to Connell Wagner to estimate queue demand and durations, but with Arup's preferred assumptions regarding stair flow rates, the following tables show the maximum boarding/alighting figures used for 2061, as well as an estimate of the maximum platform clearance for Option C.

Platforms	Alighting	Boarding	Option C Stair Width
1	551	7	5.0
3	233	180	3.6
4	63	108	4.0
5	169	98	4.0
6	23	91	6.5
7	266	102	6.5
8	24	23	4.0
11	312	79	2 Up esc 3m Stair
12	25	58	

Table 4: 2061 Peak Boarding and Alighting volumes and Option C stair widths

Platform	Maximum Queue per Stair	Plat Clearance
P1	150	105
P2/P3	91	120
P4/P5	91	75
P6/P7	80	75
P10 (for P11/P12)	139	120
P11/P12	76	60

2061 data

Table 5: Maximum queue (for each stair) and platform clearance times (seconds) at 2061

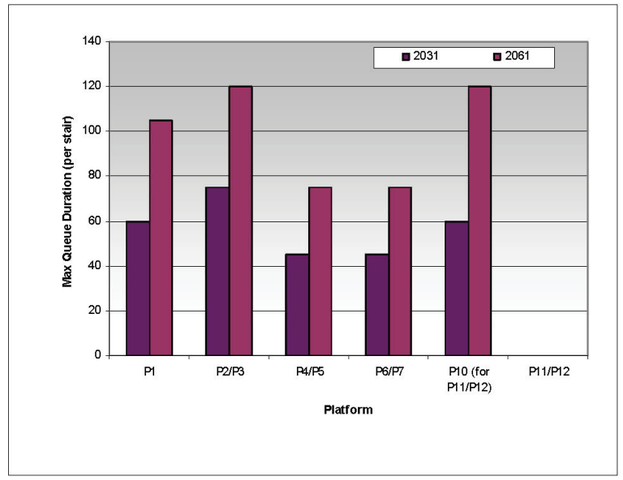

Figure 8: Estimated platform clearance times for Option C at 2031 and 2061

The platform clearances for P1, P2/P3 and P10 (for travel to P11/P12) are all above the 90 seconds maximum criteria and additional vertical transport is required. Given platform width is constrained the design team will need to investigate:

- A mix of stairs and escalators where possible
- The option of using the existing northern end to relieve interchange movements
- Providing additional VT on P10 – or preferably an alternative passage for P11/P12 passengers

The table below indicates the VT provision required to meet a 90 seconds clearance time. Given platform space is limited – especially for P2/P3, there is limited opportunity to increase VT to 4.4m. Arup recommend examining both interchange and entry/exit movements in more detail in order to test what benefits can arise if we maintain the existing stairs at the northern end to manage interchange flows.

Platforms	Alighting	Boarding	Required VT width	Train Freq
1	551	7	5.8	7
3	233	180	4.4	20
4	63	108	4.6	20
5	169	98	4.6	12
6	23	91	6.5	20
7	266	102	6.5	18
8	24	23	-	10
10	P11/P12 transfers		6.5	-
11	312	79	2 Up esc 3m Stair	18
12	25	58		18

Table 6: Stair width requirements to meet 90 second clearance time at 2061

3.3 Option D & Option E

The analysis of the VT provision performance proposed within Options D and E identified that the platform clearances times for all platforms except P2/3 and P11/12 were above the 90 seconds maximum criteria.

Table 3 below indicates the VT provision required to meet a 90 seconds clearance time for Options D and E.

Table 7 Options D and E Vertical Transportation Requirements

Platform	Options D&E Stair Width (metres)	Required Stair Width (metres)	Required Width Increase (metres)
1	2.0	5.8	3.8
2 / 3	2.0 & 2 Escs	4.4	-
4 / 5	2.1	4.6	2.5
6 / 7	2.9	6.5	3.6
10 (to 11/12)	4.0	6.5	2.5
11 / 12	3.0 & 2 Escs	3.0 & 2 Escs	-

A summary of the additional findings of the Options D and E review are as follows:

- Whilst platform clearance times from P2/3 will be significantly reduced given the additional VT capacity, the placement of the stair encourages greater usage of P4/P5 for passengers choosing to travel around the city circle (clockwise).
- The placement of stairs at the southern end of the new P2/P3 extension creates a journey time from concourse to platform which is significantly higher than alternative platforms i.e. P5 (city circle clockwise) and P7 (city circle anticlockwise).
- Given no additional VT points connecting the platform levels to concourse, station exit/entry and interchange flows will conflict and compete. As existing, congestion is likely given the bi-directional nature of the flow.
- Option E is very similar from a pedestrian capacity point of view to Option D, but with a new unpaid connection to the southeast towards the ATP and a new gateline from this connection. Although this provides a favourable connection for passengers heading to the southeast, this station access will not notably affect the paid station movements and congestion issues.
- Neither Option D nor Option E offer sufficient VT capacity to meet the platform clearance criteria for the key platform issues at Redfern Station. Alternative designs

are required to meet the entry/exit and interchange function of the station. In particular, a design that achieves separation of the primary flows is recommended, such as through the introduction of a centrally placed concourse, with additional VT points located centrally across the platform.

A summary of the Options D and E platform clearance time analysis for 2061 demand levels are presented below on Table 8:

Table 8 Options D and E Platform Clearance Time Performance, 2061

Platform	Demand (pax in peak min)		Stair Width (metres)	Max Queue (per stair)	Platform Clearance Time (secs)
	Alighting	Boarding			
1	551	7	2.0	85	120
2 / 3	0 / 233	0 / 180	2.0 & 2 Escs	24	60
4 / 5	63 / 169	108 / 98	2.1	53	120
6 / 7	23 / 266	91 / 102	2.9	110	120
10 (to 11/12)	-	-	4.0	35	60
11 / 12 (Option D)	312 / 25	79 / 58	3.0 & 2 Escs	76	60

The placement of stairs at the southern end of the new P2/P3 extension creates a journey time from concourse to platform which is significantly higher than alternative platforms i.e. P5 (city circle clockwise) and P7 (city circle anticlockwise). Whilst platform clearance times from P3 will be significantly less given increased VT, the placement of the stair encourages greater usage of P4/P5 for passengers choosing to travel around the city circle (clockwise). P4/P5 has no additional VT and has a predicted clearance time above 150 seconds at 2061 so we may just be pushing the problem elsewhere. However, this strategy may be necessary to encourage a greater share of P1=>P5 vs. P1=>P3 movements and with the right design could be used to good affect given P4/P5 is wider the P2/P3. In addition, given the stair captures a higher proportion of the train doors (by distance) we are still likely to get bi-directional flow on the stairs which is likely to be highly congested.

If an extended bridge were to be considered, then an alternative design could be the placement of 3 single escalators in series. The two most southern escalators would operate UP in the AM peak and the one closest to the concourse would operate in the DOWN direction. A design like this would encourage alighting passengers to exit the train away from the northern end, whilst allowing entry passengers to use the escalator closest to the concourse. The interface (and in particular the width) at the concourse/bridge would need to be examined carefully as would the impact of other platforms (P1 and P5 in particular).

Option E is very similar from a pedestrian capacity point of view to Option D, but with a new unpaid connection to the south east towards the ATP and a new gateline from this connection. The Platform 10 stair to ATP is also removed. Neither Option D nor Option E meet the platform clearance criteria for the station and alternative designs are required to meet the entry/exit and interchange function of the station.

4 Conclusions

The following table indicates the key points that have been raised during the peer review process and the recommendations during the revised concept design process. This table forms a checklist to be considered during the subsequent stages of the project.

Topic	Action
2061 vs. 2031 demand	Option D and E will be unsuitable to cater for 2031 demand (except P2/P3). Given 2061 demand is unconstrained, are RailCorp satisfied with the design and hence platform clearances based on 2031 demand or 2061 demand.
P1 and P11 interchange movements	75% of all interchange movements (14,000 at 2061 during 3.5hr pk) are driven by either P1 or P11. The movement from P1 to P3, P5 or P7 needs to be clearly considered and tested. Recommend simple simulation models to identify issues and test widths of concourse areas and VT capacities.
Stairs vs. Escalators	Choice of flow rates to be reviewed with RailCorp. Choice recommended in this report is aligned with observations at Town Hall, Wynyard and Burwood. In addition, they're a mid point between design recommendations from MTR (63ppm) and London Underground (35ppm). Have we got the correct mix of stairs and escalators to meet the P1 and P11 interchange movement – and the considerable entry / exit flow.
Performance Metrics	Is 90 seconds an acceptable clearance criterion? Can we have an exception for P1 given the 7tph service?
External Influences	Poor data capture relating to external station movements is a risk item and will influence the new location for the station entrance. We need to agree either to use the data in section 2.2.1 or we need to undertake a small survey looking at counts externally to the station

RailCorp

Redfern Station Upgrade - Concept Design

Engineering Peer Review Report

ARUP

RailCorp

Redfern Station Upgrade - Concept Design

Engineering Peer Review Report

February 2009

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		Signature			

Issue Document Verification with Document ✓

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Appendices

1 Introduction

1.1 Scope

Arup has been engaged by RailCorp to progress the concept development planning of Redfern Station to the project definition stage, on the basis of work undertaken by Jackson Teece / Connell Wagner in 2007. The anticipated outcome of the design progression is a refined concept design that can be used as the basis for a business case submission by RailCorp for government funding.

This report is a peer review report undertaken at the commencement of the engagement, to review the concept design options C, D and E developed by Jackson Teece. Specifically, in recognition of the RailCorp User Requirements, it is to include a review of the following:

- Adequacy in meeting RailCorp fire life safety requirements, including emergency evacuation
- Engineering and structural constraints imposed by the 'exclusion zone' for the proposed metro west dive,
- Engineering and structural constraints imposed by building over operating rail track and minimising scope and scale of built structures and functions in this area;
- Capacity to accommodate cost effective design improvements that address the results of crowd modelling, constructability/architectural input and other stakeholder inputs, taking into account the whole of life cycle costs.

1.2 Background

Previous studies have been undertaken on the upgrade of Redfern Station prior to this study. The most significant of these studies is the most recent study undertaken by Jackson Teece in 2007, in conjunction with Connell Wagner and Tenix. Appendix A provides a schedule of our understanding of the reports prepared regarding Redfern Station prior to this report.

1.3 Methodology / Approach

The objective of the peer review is to analyse the design prepared to date at a high level and provide comment with regard to cost effectiveness, constructability, and compliance with existing standards and requirements. The review also includes comment on the completeness of the design prepared to date, and the extent to which known issues are examined to the extent required for a RailCorp concept design.

This peer review has been undertaken with a focus on civil / structural, fire engineering and rail systems engineering issues. For each discipline, the available information is reviewed and comments provided, addressing the requirements of the brief outlined above.

For each discipline, the scope of the peer review is described below:

Civil / Structural Engineering

Review of project wide issues and risks, followed by a review of the proposals put forward for each concept design option.

Fire Engineering

Review of reports prepared in relation to each design option, as made available.

Rail Systems Engineering

Review of reports prepared for each design option, as made available.

1.4 Peer Review Reference Documents

The specific documents forming the basis of this peer review are the following:

- Redfern Station Redevelopment Project - User Requirements (v1.2), RailCorp, March 2007
- Concept Design Study - Part A - Urban Design Report, Jackson Teece, April 2007
- Concept Design Study - Part B - Engineering Report, Connell Wagner, April 2007
- Signalling Concept, Connell Wagner, April 2007
- Cost, Constructability and Programming Review, Rev 3, Tenix, April 2007
- Redfern Station Review - Review and Clarification to Apr 2007 report, Tenix, February 2008
- North Eveleigh Dive and Tunnel Alignment Concept Design Corridor Protection Drawings SK100-105, SK110-112, SK121-124 and SK130-134, Connell Wagner, 2/10/07
- Geotechnical Investigation Proposed Pedestrian and Cycle Bridge, Jeffrey and Katauskas, September 2008

2 Civil / Structural Engineering Peer Review

The civil / structural engineering peer review has been undertaken as follows:

- consideration of the generic project issues and risks which appear on all options
- review of Options C, D and E with specific attention to those options

Civil/structural aspects of Options D and E have not been addressed in the Connell Wagner Concept Design Study Report Part B - Engineering Reports. Hence, for these options, the peer review has been based on Concept Design Study Report Part A – Urban Design Report and the Cost, Constructability and Programming Review.

2.1 Project Issues and Risks

The following project risks have been identified and summarised in Section 3 Project Risks of the Structural Design Philosophy Report:

1) Geotechnical information
2) Lateral analysis of buildings
3) Illawarra Relief Structural Information
4) Location of engine dive tunnel under platform 1
5) Underground services
6) Site boundaries
7) Level of structural design

Our comments on these project risks are given in the following sections.

2.1.1 Geotechnical Information

This project risk is significant, and remains a significant risk item. Since the preparation of the concept design report, some geotechnical information associated with the Eveleigh Heritage Walk has become available. It is noted that this information relates only to the northern side of the site, and so does not address the fundamental project risk.

2.1.2 Lateral Analysis of Buildings

It is noted that the lateral analysis of the buildings has not been considered due to time limitations, but that the concourse has been considered. It is important that this is considered in any future studies to provide confidence that the proposed scheme is feasible.

2.1.3 Illawarra Relief (IR) Structural Information

The report notes that a structural survey of the IR is required to confirm the structural capacity of the existing structure. While this is required to confirm any option to support new structure on existing structure, this is considered to be a high risk approach. We recommend that new structural supports be established for the new building.

2.1.4 Location of Engine Dive Under Platform 1

This is a significant risk to the geometric arrangement for all works around Platform 1.

2.1.5 Underground Services

This risk is significant, but it is acknowledged that it may be a residual risk that will continue throughout the project. It should be noted as a residual risk that needs to continue throughout the project.

2.1.6 Site Boundaries

This risk relates to the constraints imposed by site boundaries on the design solution. It is anticipated that the site boundaries should be able to be determined, and this risk is addressed during the design.

2.1.7 Level of Structural Design

Not relevant to project risks

2.2 Proposed Metro West Dive Protection Zone

In addition to the above project risks, the brief requests that a review is undertaken on the constraints imposed by the proposed metro west protection zone. These are discussed below.

The protection zone for the proposed metro west dive was not been addressed in the concept design study. RailCorp have provided concept design drawings for the North Eveleigh dive and tunnel alignment corridor protection for consideration in the peer review. These drawings have an issue date of 2 October 2007 and are noted as 'draft' and 'not for distribution'. RailCorp should confirm that the information shown on these drawings is current.

The drawings clearly indicate the boundaries of the proposed protection zones in relation to Redfern Station for Option 1 and Option 3 alignments and specify the protection requirements for each zone. It is assumed that protection zones for both Option 1 and Option 3 alignments are to be adhered to. Option 3 alignment runs north of Option 1. If Option 3 were adopted over Option 1, the southern edge of the protection zone would be offset about 5-6m further north and have less affect on Redfern Station.

Fig.1 shows the protection zone overlayed on Redfern Station Redevelopment Option C and Fig. 2 shows a section through the protection zone at the east end of Redfern Station.

The northern edge of the protection zone (toned turquoise) lies north of Little Eveleigh Street. Platform 1 lies entirely within the protection zone. The southern edge of the protection zone (toned turquoise) affects the majority of Platform 2 and the north eastern end of platform 2/3 beyond the heritage building, but the remaining part of the station is not affected.

The condition for the turquoise toned protection zone (see Fig. 2) is that structures cannot be founded on or in the zone, although piles may pass through it. Piles passing through the protection zone can be located within about 2.5 - 3.0m of either edge of the protection zone, without affecting the tunnels or tunnel linings, etc.

The main impact of the protection zone for the proposed metro west dive on Option C is on the support structure to the concourse / bridge and stairs on Platform 1, and the concept design development should investigate the implications. Depending on the magnitude of the foundation load, type of foundation, position and bearing level, dispensation may be obtained for foundations on, or within, the protection zone.

It is not considered that the metro west exclusion zone should form a fixed constraint to the Redfern station upgrade project. Instead, it should form a basis for discussion and negotiation between the key stakeholders (both functions of RailCorp), as both projects have the potential to be mutually beneficial with the right design solution.

The status of the metro west protection zone needs to be closely monitored during the life of the project due to the development of other rail projects in Sydney. These projects may impact on the proposed use of the protection zone currently in place.

Options D and E do not appear to be affected by the protection zone.

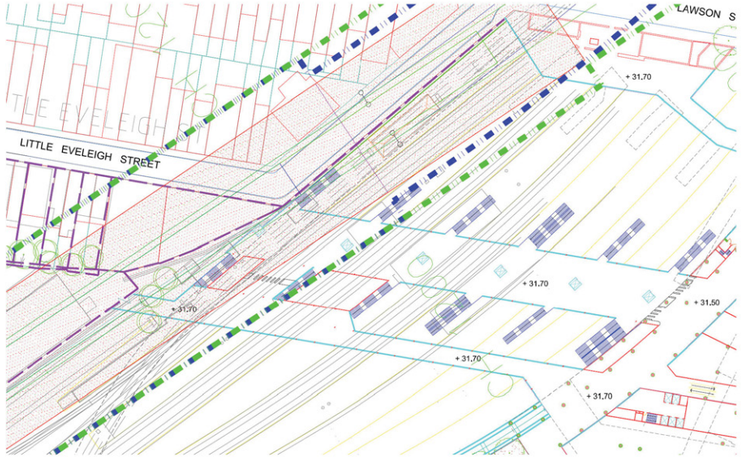


Fig.1 Protection zone overlayed on Option C

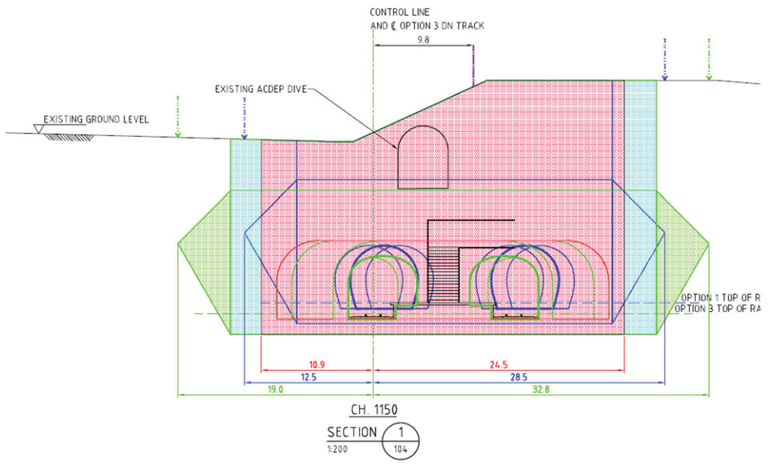


Fig.2 Section through the protection zone at the east end of Redfern Station

2.3 Assumptions

Various data was made available to the concept design study consultants. In some cases insufficient information was available requiring the consultants to make assumptions. The significant assumptions adopted in the concept design and possible implications are summarised below:

	Assumption	Risk	Required Additional Data / Advice
Geotechnical	Rock at RL 18m or above. 3500kPa allowable bearing capacity	Lower bedrock RL and/or lower bearing strengths than assumed	Geotechnical site investigation for Redfern Station
Existing Structure	Caveated assumption that could take new imposed loads.	Works may be more extensive and costly than currently provisioned	Structural survey of IR and station
Survey	Site boundary not located		Add site boundary to survey Site survey of the engine dive tunnel to confirm exact location of tunnel walls and roof Site survey of the in-ground and above ground services at the station and within Gibbon Street
DSS railway tunnel		Preferred column grid may not be feasible	Confirm whether the DSS railway tunnel is permanently disused

2.4 Option C

The proposed structure comprises a precast prestressed concrete plank concourse structures supported on insitu concrete headstocks over platforms. The headstocks are supported by insitu concrete columns on pile caps and piles.

We have the following peer review comments on Option C:

2.4.1 Concourse

The general approach of a precast concrete concourse structure over insitu platform support structures is appropriate and valid. This structural approach provides the most effective solution for dealing with constructability, durability and fire resistance issues.

It is appreciated that the structural design prepared is a response to the developed architectural concept. It is noted that some reductions in project scope may be achieved, through a renewed design approach.

The separation of the paid and unpaid concourses in the current configuration increases the scope of construction work and maintenance over the live railway corridor. We recommend that this be reviewed.

The concourse structure spans are in the order of 18-20m with the current skewed arrangement. If the concourse was rotated to be perpendicular to the railway, the span

would reduce to 14-17m. This reduction in span will reduce the structural sizing throughout the system, as well as simplify construction details.

The current concourse layout and orientation necessitates the removal of several OHW gantries. It is recommended that the design be revisited to investigate if fewer gantries could be removed, or if the concourse could pass above the gantries (with associated platform access and street level issues). It is recognised that the heritage buildings on the platforms form a significant constraint to the available locations for platform access (assuming their retention).

As a general approach, project risks are minimised by adopting an approach to build as little over live railway corridors as possible. This not only provides benefits during the construction period, but also during the life of the building. Maintenance of structures over railways is a key issue in the operation of the rail network, and the minimisation of this is preferred. In particular, water services should be relocated away from operating railway. The drawings indicate back of house, staff amenity and public toilet space over the railway and platforms 3 and 4. It is recommended that this space be relocated to another location, to remove it from the live rail corridor, and remove the maintenance issue of having water services over live railway.

It is noted that piled foundations are restricted from being within 2.6m of the platform edge, due to platform clearance requirements. This restriction is not deemed to be real, as the pile top will be below platform level, meaning that a temporary platform can be constructed over during non-work periods. This method of work was successfully used on the Parramatta Station Upgrade project. The restriction will most likely be to live OHW, and any critical platform services that may be present under a platform.

The butterfly awnings steel framing and support appears reasonable.

The concourse roof and side wall framing appears reasonable as a steel structure supported on a precast concrete deck. Consideration will need to be made for maintenance and cleaning of the exterior of this building as the design progresses.

The Tenix report proposes the construction of a temporary construction access bridge at the southern end of the platforms. We consider that this proposal needs to take account of the requirements of ESC320 and AS5100 with regard to overbridges. It is not evident that a waiver could be obtained for a footbridge of this scale.

2.4.2 Platforms

The user requirements specify that level access is provided to all platforms, in conjunction with all platforms sloping away from the platform edge. The means by which this is achieved is not discussed in the Engineering Report. This will need to be addressed during the current works due to the knock-on effects of raising the platform coping and changing the drainage profile of the platform. The common issues are:

- platform drainage provisions (typically none current provided)
- access to existing services that may be buried within platforms
- interfaces with platform buildings (and existing thresholds)
- effects on existing platform furniture (seating, canopy posts etc)

2.4.3 Building Development

Two options have been presented for the support of the building development over the Illawarra Relief structure. A recommendation is not provided. Upon initial review of the information, we recommend a scheme similar to 'Option A' be considered as the preferred option, due to its reduced scope of works in the rail corridor beneath. This option also requires considerably less intrusive investigation of the existing structure which is in operation, which presents a lower risk.

There is discussion regarding the proposed construction of a four storey building above the northern ends of platforms 8, 9 and 10. It is noted that this building does not feature in any of the final design options proposed in the Jackson Teece report. As such, it is not reviewed in this report.

2.5 Option D

Option D has not been addressed in the Concept Design Study Report Part B – Structural Engineering Report, prepared by Connell Wagner.

Tenix assessed Option D in their 'Cost, Constructability and Programming Report'. The constructability assessment places most items as relatively minor works, which are undertaken within overnight and weekend possession programmes. Most of the items are fit-out or configuration changes, rather than major civil / structural items.

We have the following peer review comment on Option D:

- It is proposed to install lifts at the northern ends of the platforms. There does not appear to have been an assessment undertaken of the impacts of this on the existing concourse structure, or the existing supporting structure.

2.6 Option E

Option E has not been addressed in the Concept Design study Report Part B – Structural Engineering Report, prepared by Connell Wagner.

We have the following peer review comments on Option E:

- There has been no structural work undertaken on the feasibility of extending the concourse by 3m. In consideration of the lack of information available on the existing concourse structure, and that the work is located directly over live rail, this option requires further analysis to determine the associated risks.
- RailCorp standard ESC320 explicitly requires that the replacement or refurbishment of an existing overbridge initiates a requirement for the structure to comply with AS5100. This has potentially significant implications for Option E, as while the structural modifications may appear moderate in scale, they will most likely require compliance with the modern code, resulting in significant structural works being required. Without waivers being successfully sought, these structural works could include replacement of the existing buildings and footbridges.

3 Fire Engineering Peer Review

The key requirements for fire safety are set out in the User Brief (Ref 2007.03. 12 User Requirements Redfern Version 1.2), Section 3.2. The requirements are broad in their extent and set a high standard for fire and life safety. These are referred to in part in the fire engineering sections of the Concept Design Study and engineering reports. These generally assume that the design must comply with NFPA130, however, these are only guide documents in NSW.

3.1 Option C

3.1.1 Preliminary Service Recommendations

The recommendations in the Preliminary Service Recommendations report were prepared for Option C only. It makes recommendations for services to above ground areas. It does not provide a comprehensive list of the fire services to be required, and refers to BCA requirements guidance, which would be insufficient for RailCorp's purposes.

Platforms 11/12 was stated as requiring advice from a fire safety engineer. A detailed fire engineering assessment should be carried out as soon as possible, because it could have a significant impact onto the architectural layout planning, particularly if smoke control is required.

No fire safety upgrade details were included in the study report.

3.1.2 Pedestrian Evacuation & Fire Engineering Report

Two new emergency stairs from Platforms 11 and 12 are noted as being required. The location of these has not been co-ordinated with Jackson Teece.

The calculation of passenger numbers, waiting to board a train prior to an emergency appears is not clear. It appears that the platform numbers are based on the arriving train load, which would be incorrect. This may underestimate the number of platform occupants.

The methodology for estimating the time to clear the platform appears to be incorrect as the capacities of two exit elements (platform to concourse and through fare barrier) arranged in series have been added together (the lower value would determine the queuing time).

The methodology for estimating the time to evacuate to a point of safety outside the station appeared to be incorrect as the concourse occupant load has been estimated to be zero. There will be people present, especially at peak times. These additional occupants could increase queuing times (depending on number, and whether they may leave before the majority of platform occupants arrive).

The provision of evacuation plans on platforms is considered to be ineffective as passengers are unlikely to read them during an emergency. Emergency management procedures, occupant warning messages, signage and good layout of exit routes will be the key item for egress.

3.1.3 STEPS Pedestrian Simulation Modelling Results

The assumptions and input parameters documented in the Connell Wagner report were insufficient to determine if the modelling has been carried out correctly.

Several key aspects have not been modelled according to Section 3.1 of the report, including passengers arriving from Platform 1, and waiting on the concourse for the next Town Hall or Wynyard service, hence the modelling results could be considered to be of little relevance for evaluating the options.

The STEPS simulation carried out for Option C may not adequately model the occupant scenarios.

3.1.4 Discussion

Option C provides the better option for evacuation from above ground platforms, because it has extra stair width. The two 2 m wide stairs from each of the platforms above ground may not achieve the egress times stated. It is estimated that the busier platforms would each require exit width of up to approximately 3 stairs each approximately 3 m wide (total 9 m) to provide a "compliant" stair width (i.e. achieve a 4 minute queue time). Clearly, the actual width from a platform is likely to be less than 9 m total, due to platform width constraints. However, it is recommended that the existing stairs be retained, in addition to providing the new stairs, to provide the maximum practicable exit width capacity from the platforms.

No assessment was made for Platforms 11 and 12.

A further assessment is required of all possible occupant loads, and flow times for the platforms to be confident of the actual egress times.

There is no information available for the other fire safety requirements, such as fire resistance, options for smoke extract for Platforms 11 and 12 (including omitting smoke control) and other fire safety systems.

Jackson Teece (Urban Design Study - Section 5. Non-compliance with the User Requirements. Item 3.2) state that Option C complies with FLS requirements; however, the exit capacity does not comply.

There is no information regarding the other fire and life safety systems to support this. Clearly, with the constraints of an existing station, it may not be possible to comply with other current fire and life safety standards; however the fire engineering work to date does not adequately discuss this.

3.2 Option D

3.2.1 Preliminary Service Recommendations

The recommendations were prepared for Option C only, which would need to be extended to cover Options D and E for a complete cost benefit analysis.

3.2.2 Pedestrian Evacuation & Fire Engineering Report

The comment on Option C above applies, other than only one egress stair to be provided.

3.2.3 STEPS Pedestrian Simulation Modelling Results

The modelling did not include Option D. A detailed STEPS simulation with all key relevant characteristics of Option D included could be carried out if comparison is required.

3.3 Option E

3.3.1 Preliminary Service Recommendations

The recommendations were prepared for Option C only, which could be extended to cover Options D and E for a complete cost benefit analysis.

3.3.2 Pedestrian Evacuation & Fire Engineering Report

The comment on Option C above applies.

3.3.3 STEPS Pedestrian Simulation Modelling Results

The modelling did not include Option E. A detailed STEPS simulation with all key relevant characteristics of Option E included could be carried out, if this option were to be explored further.

4 Rail Systems Engineering Peer Review

The rail systems engineering peer review has addressed Option C works as described in Sections 1, 6 and 7 of the Concept Design Study Report Part B - Engineering Reports.

Rail systems aspects of Options D and E are not addressed in the Part B – Engineering Reports although some mention is made in the Part A Report.

4.1 Option C

4.1.1 Preliminary Service Recommendations

The recommendation that new station substations are required because the existing station substations have insufficient capacity for reuse and insufficient space for upgrade appears reasonable, although this has not been verified. There is no stated basis for the estimated maximum demand for the final configuration and the adoption of 2x 750kVA substations. The maximum demand and required kVA of the substations needs to be verified.

The discussion of the separate electricity supply arrangements for the station and development site does not mention the significant issue of creating electrical discontinuity between the station and development site structures (to prevent electrolysis) and segregating the earthing systems. Chatswood Transport Interchange (CTI) is a recent example of how earthing systems can be problematic; although the CTI solution is not applicable here due to the ballasted track form which has much lower electrical resistance than the track form used at CTI.

4.1.2 Scope for OHW Traction

The scope of works for OHW traction works for Option C is shown on Connell Wagner drawing OH-SKETCH-001.

The approximate average contact wire height is noted as 5.0m. Information has been obtained which indicates that the contact and catenary heights ramp up progressively from ~4.75m and ~5.5m respectively to ~5m and ~6.5m respectively from the existing concourse towards the country end of the platforms. The approximate average portal structure height is noted as 7.0m, but is typically around 8m above rail. Survey drawings indicate a maximum height above rail level of 8.2m.

Connell Wagner advocate adoption of 6.1m clearance to the concourse soffit above rail and not attaching the OHW to the new concourse. This is a low risk solution but it provides a poor outcome in terms of concourse deck height and complexity of the final configuration. We consider that more effort should be put into exploring a bridge deck design specifically designed for constructability and maintainability, while supporting the OHW. This will also minimise the need for additional structure legs on the platform, with attendant touch potential issues. Ease of maintenance is not known to be a valid reason for not attaching to the underside of the concourse. It should be noted that Option C has a concourse level of RL 31.7 which provides a clearance of 5.7 m above rail, allowing for a structural depth of 800 mm including insitu topping and finishes. Therefore, there appears to be a conflict between the Option C concourse levels and the recommendations made by Connell Wagner.

4.57m contact wire height under the concourse is too low. 4.75m is considered to be a more appropriate design objective.

We agree that modifying the existing OHW support structures is not a good option.

It is recommended that a concept design of OHW and bridge deck be carried out for two tracks only as a case study to explore what can be achieved. The arrangement will have to allow the bridge beams to be placed quickly to allow the OHW team time to attach the OHW to the beams during the same possession. The overhead wiring conversion work in this vicinity was not conducted that long ago and RailCorp Electrical Engineering Services

should be approached to obtain sufficient data to plot OHW profiles (long sections) for the tracks concerned.

4.1.3 Signalling Concept

Adjustment of two signals is addressed in the signalling concept section of the Engineering Report. Signal SY455 fitted to a gantry structure between the SW ends of platforms 1 and 2 will be impacted by the new concourse. Extending platform 9 towards the road bridge to minimise traffic at the narrow south-west end of the platform is impacted by the position of signal SY466.

Signal SY455

Relocation of the signal approximately 20m towards Central (Option 1) is likely to be practical. The only issue to check is the possible blocking of 266 points if a train must stop 20m closer to Central. The cost is likely to be significant as a new gantry would be required with the signal, block joint and train stop to be relocated.

Redesign of the profile of the signal to reduce the overall elevation (Option 2) could be practical. Exploring a technology that allows the signal heads to be raised to gantry level rather than accessed from within a cage might allow a narrower assembly that could be positioned lower to achieve better sighting under the concourse. Such an arrangement would also eliminate the safety issues with the cage arrangement.

Relocation of the signal onto a post-mounted structure on platform 1 (Option 3) is not considered to be practical as the signal would have to be set back significantly from the platform coping and sighting would be a problem.

Signal SY466

It is agreed that moving signal SY466 more than a few metres towards Central will not be practical. The limit would be having the train-stop clear of the bridge pier for ease of maintenance. Unless the country end of platform 8/9 narrows very rapidly, a small extension on the Sydney end is unlikely to make a significant difference to the problem at the country end. The option of extending only platform 8 appears to be useful. Platform 8 is the Down Illawarra Local and presently sees much more traffic than platform 9 which serves the Up Illawarra. This option may also reduce the need for service relocations – a number of services are evident in the photo.

Note also that platform 9 could be physically extended to the same point as platform 8. However, the location of the 8 car platform mark would remain substantially unchanged in order to have the required set-back from the signal.

4.2 Option D

The assertion in Section 2.3 of the Part A report that the concourse extension above platform 2/3 can avoid conflict with the OHW by reducing its level by 1400mm may be overly simplistic. The underside of one of the portal booms is at 7.8m above rail. If the FFL of the new walkway is at 4.8m above rail then fitting the walkway under the portal boom would be tight. Several of the existing portal legs would penetrate the new walkway and the knee-braces would have to be accommodated or re-worked.

It is agreed that the signal sighting issues would have to be further investigated.

4.3 Option E

Apart from the extension to the concourse and the recognised additional impact on the OHW Option E is essentially the same as Option D in terms of impacts on OHW and signalling and the comments above relating to Option D also apply to Option E.

5 Conclusions

5.1 Capacity for Design Development

There appears to be capacity for further design development to refine costs prior to presentation of a preferred concept design option for government approval. Much of this capacity lies in the integration of engineering and architecture. The design reports prepared give the impression that the engineering solutions are a direct response to the architectural solutions proposed. With the engineering forming a significant cost element of the works, we believe that savings can be made through the incorporation of engineering issues into the overall station planning decisions.

5.2 Summary of Key Issues

To provide clarity, we provide the following summary of the key issues that should be addressed in the revised concept design as a result of this peer review.

1. Pursuit of reduction in extent and area of concourse structure built over the rail corridor
2. Investigation of design to reduce the effects on existing OHWS, and minimise the replacement works that result
3. Removal of BOH and toilets, and resulting services, over the live rail corridor
4. Clarify requirements to provide level access on platforms within the scope of this project (consideration of network track works that are currently planned)
5. Review of evacuation egress capacity for the station, including platforms 11 and 12
6. Clarification of compliance with FLS standards
7. Clarification of maximum demand calculations
8. Relocated position of signal SY455

Appendix A

Previous Studies

A1 Previous Studies

Date	Rev	Author	Title
Jan 1996		Devine Erby Mazlin	Redfern Station Concept Design
Jul 2002		PPK	Transport and Movement - Redfern Station Redevelopment
Jun 2003		JTCW	Development Study for Redfern Station
Jan 2004		Stafford Moore Architects	Redfern Station Design Development
Mar 2004		RailCorp	Redfern Station Upgrade Options
Feb 2006		Paul Davies Architects / Wayne McPhee and Associates	Heritage Conservation Report
Aug 2006		Redfern Waterloo Authority	Built Environment Plan
Oct 2006	1	RailCorp	Redfern Station Redevelopment Project - User Requirements
Dec 2006	0	Tenix	Preliminary Working Report (Rev 0 of CCP report)
Dec 2006	2	RailCorp	Redfern Station Redevelopment Project - Practical considerations and constraints during construction
Dec 2006	1.1	RailCorp	Redfern Station Redevelopment Project - User Requirements
Feb 2007		Australian Centre for Value Management	Redfern Station Upgrade - Principal Options Assessment Workshop
Mar 2007		Jackson Teece	Discussion Paper - Selection of Preferred Options
Mar 2007		Connell Wagner	Pedestrian Evacuation Report
Mar 2007		Connell Wagner	Preliminary Services Recommendations
Mar 2007		Connell Wagner	Fire Engineering Report - Pedestrian Evacuation
Mar 2007		Connell Wagner	Structural Engineering Report
Mar 2007	1.2	RailCorp	Redfern Station Redevelopment Project - User Requirements
Apr 2007		Jackson Teece	Concept Design Study - Part A - Urban Design Report
Apr 2007		Connell Wagner	Concept Design Study - Part B - Engineering Report
Apr 2007	3	Tenix	Cost, Constructability and Programming Review
Apr 2007		Connell Wagner	Requirements for vertical circulation under peak normal AM loads
Apr 2007		Connell Wagner	Signalling Concept
Jul 2007		Connell Wagner	STEPS Pedestrian Simulation Modelling Results
Jan 2008		Maunsell	Preliminary Economic and Financial Evaluation of Redfern Station Upgrade
Feb 2008		Tenix	Redfern Station Review - Review and Clarification to Apr 2007 report

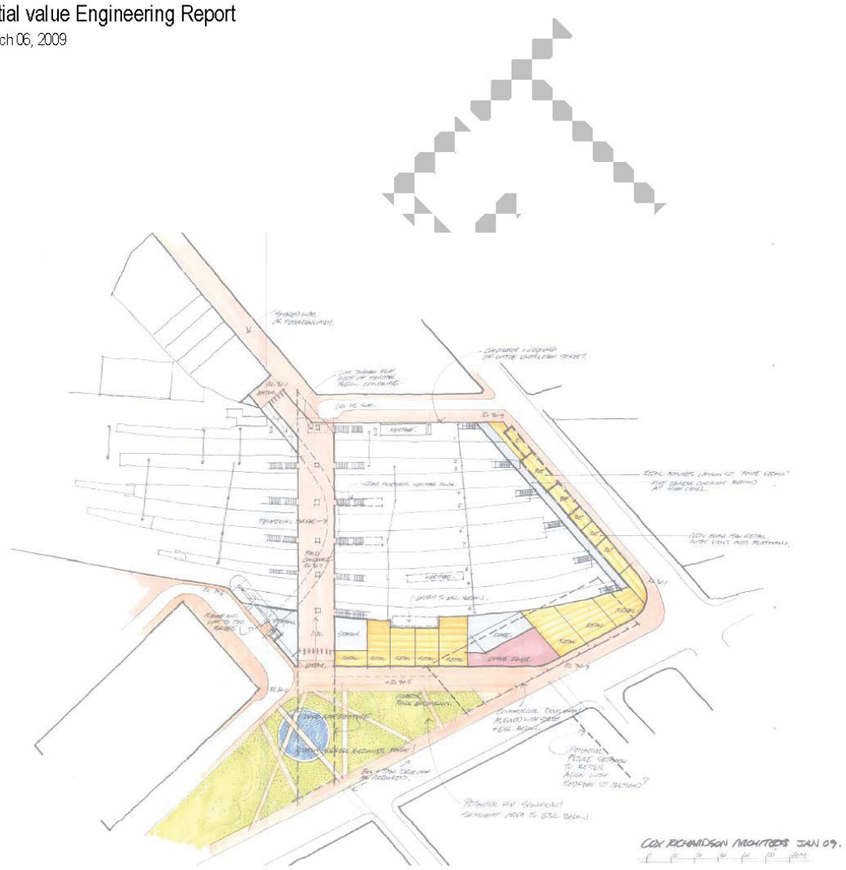
Bovis
Lend Lease

Imagine
Create

Redfern Station Redevelopment

Initial value Engineering Report

March 06, 2009



DRAFT

This report is currently in a draft status. Until such time that it has been reviewed and accepted by RailCorp will this status be amended by removing the draft notification.

Bovis Lend Lease

Contents

Bovis Lend Lease

Executive Summary

This initial Value Engineering report has been prepared by Bovis Lend Lease Consulting (BLLC) in addition to their role as Project Manager for the project: *Redfern Station Redevelopment – revised concept design*. In order to create the best value for the Redfern Station Redevelopment to RailCorp, an initial value engineering study and associated workshops have been undertaken.

In summary the review of relevant documentation and new work undertaken including value engineering workshops held by BLLC with the design team resulted in 22 value engineering items that were reviewed and investigated. These items generated alternative design solutions which are considered to be in accordance with RailCorp's user requirements. The detailed items are described in paragraph 2.2.

It can be concluded that the 22 items have the potential to achieve cost reductions, shortened construction durations, enhanced building value, enhanced customer experience, increased safety of construction and maintenance works and increased value to the customer. The proposed possession timetable has the highest impact on the construction method, the concourse alignment has the highest impact on the design and the car park, retail buildings and enabling works have the highest impact on procurement strategy or staging.

Incorporating these value engineering items into the revised concept design for the Redfern Station Redevelopment will significantly add value to RailCorp

Following this initial value engineering report it is recommended that all 22 items be further reviewed by a cost and constructability consultant to provide further information relating specifically to cost estimates and construction durations.

1. Introduction

This initial value engineering report has been prepared by Bovis Lend Lease Consulting (BLLC) in addition to our role as Project Manager for the Redfern Station Redevelopment to oversee studies, review and refine previous concept designs, manage engineering and cost reports and coordinate value engineering sessions.

RailCorp and Redfern Waterloo Authority (RWA) have been working co-operatively on a number of options for the redevelopment of Redfern Station and this has resulted in the concept design of a preferred option: "option C – full station redevelopment". This option achieved the best outcomes in relation to the long term planning needs for the station upgrade, the user requirements, and improved safety and security compared to the other options developed in the previous concept design (Jackson Teece). Option C provides a new elevated concourse above the centre of the platforms and allows for easier passenger flow through the station and population of the concourse. It includes an unpaid pedestrian access across the rail line for non-rail users in line with the overall station concourse structure.

In order to create the best value for RailCorp, BLLC has undertaken an initial Value Engineering study and associated workshops as part of the Redfern Station redevelopment to revise the preferred option C from the current concept design (Jackson Teece) for RailCorp. During the value engineering process the project team have reviewed and examined value engineering options raised by BLLC for items where significant cost reductions, shortened construction durations, enhanced building value, enhanced customer value and experience, increased safety of construction and maintenance works and increased value to RailCorp are possible.

2. Value engineering

For the performance of the value engineering study the analysis is broken down into a typical series of steps referred to as the value engineering plan. These steps fall within five basic phases as follows:

1. Information: investigate and select areas for detailed study
2. Investigation: generate alternatives within requirements
3. Analytical: develop alternatives and evaluate against criteria
4. Proposal: present best alternatives to decision makers (Steering Committee)
5. Final report: define and quantify results.

The next paragraph will cover the first three phases of the value engineering plan and the ranking criteria. Paragraph 2.2 to 2.4 describes the detailed value engineering items – categorised into three groups – on the basis of original design, proposed design and criteria. Once cost planner and constructability consultant have reviewed all items the design team will be able to progress the revised concept design.

2.1 Value Engineering Phases

2.1.1 Phase 1: Information

Initially BLLC reviewed the available existing documentation on the Redfern station, both the peripheral documents and the documents associated with the previous concept design completed by Jackson Teece. In addition BLLC used their knowledge and experience on other stations, including proposed concept designs, completed station upgrades as well as reviewing existing stations to assist in developing a detailed list of potential value engineering (VE) items. Some of the stations which were reviewed are North Sydney, Chatswood, Parramatta, Blacktown, Rhodes, Wynyard, Town Hall and Central. A detailed site inspection of Redfern and the surrounding area (3 km radius from the station) was undertaken to further understand the urban context and future developments in addition to both RailCorp's and RWA's objectives.

Following the review of this overall research, a detailed examination of the most recent cost report for the proposed development was undertaken. (Please refer to *Redfern Station Upgrade, Cost, Constructability and programming review,* Tenix Projects, April 2007)

2.1.2 Phase 2: Investigation

From the above research BLLC developed a list of potential VE items for initial consideration. These items are grouped into three categories:

1. Construction items
2. Design items
3. Procurement strategy items

Then an initial set of criteria to rank the various VE items was developed. An initial review of potential rankings produced a "hit list" of the first items to be considered in a value engineering context. BLLC then proposed some preliminary alternatives for the 22 nominated items.

2.1.3 Phase 3: Analytical

Following phase 2 BLLC lead a series of workshops to discuss, review and challenge the 22 items and associated alternatives raised with the design team. The Value Engineering (VE) team comprised of the following members:

- Andrew Quarmby, BLLC (VE Team leader),
- Karlijn Klawer, BLLC (Project Manager),
- Ian McGilvray, Cox Richardson (Project Director Architectural design),
- Nick Tyrrell, Cox Richardson (Project Architect),

- Andrew Henry, ARUP (Station Engineer),
- Mike Cook, ARUP (Project Manager Engineers),
- Victor Andrade, ARUP (Station/ Structural Engineer),
- David Stuart-Smith, ARUP (OHW specialist),
- Joe Paveley, ARUP (FLS specialist),
- Paul Stanley, ARUP (Project Manager Ped modeller),
- Lawrence Nassivera, ARUP (Ped modeller)

At this stage detailed input on costs and construction issues from the cost and constructability consultant is unavailable. After review from cost and constructability consultant justification and cost estimates of the proposed VE items could be provided while addressing phases 4 and 5 as mentioned earlier. This will then allow the design team to progress a revised concept design plan which maximises value to RailCorp.

2.1.4 Ranking criteria

The table below shows the ranking criteria used on the 22 VE items. Please note that at this early stage all criteria are weighted equally.

Criteria	Ranking	Ranking definition
Cost	H	High potential cost reduction
	M	Medium potential cost reduction
	L	Low potential cost reduction
	A	Potential additional cost
Construction duration	H	High potential construction duration reduction
	M	Medium potential construction duration reduction
	L	Low potential construction duration reduction
	A	Potential additional construction duration
Safety	H	High potential increased level of safety
	M	Medium potential increased level of safety
	L	Low potential increased level of safety
	A	Potential reduction to the level of safety
Project risk	H	High potential project risk reduction
	M	Medium potential project risk reduction
	L	Low potential project risk reduction
	A	Potential increase to project risk
Generally	N/A	No significant impact

2.2 Detailed items - Construction

The following VE items were raised to improve several construction related issues.

2.2.1 Possession timetable

One of the fundamental constraints on construction in the rail environment is the possession timetable. The length of individual possession, the duration of time until the following possession of the same configuration and the configuration of the possession has a significant impact on both the time and cost of the project.

Due to the significant impact of this component on the project and the lack of previous work on possessions for the Redfern Station Redevelopment project, RailCorp and BLLC undertook an immediate review of possible possession timetables. The objective was to create a possession timetable which could both significantly reduce the cost of the project and be possible within the possessions constraints.

After several meetings with the departments in RailCorp responsible for possessions and time tables the principal alternative possession timetable was agreed. This possession timetable will be used to progress the concept design and after Treasury Gateway approval this timetable needs to be confirmed and locked in as soon as possible. Please refer to appendix A for the meeting minutes and proposed/ agreed possession timetable.

Criteria	Ranking
Cost	H
Construction duration	H
Safety	H
Project risk	H
Other notes	N/A

2.2.2 Temporary crash deck

The construction method described in the Tenix report required a temporary crash deck to be supplied, erected and then later dismantled all of which is both costly and time consuming. BLLC and the design team reviewed the options and have developed a method of design and construction that removes the need for a temporary crash deck.

Based on the proposed possession timetable platform 1 and 10 will be closed for public for a longer period of time (not simultaneously) to allow for a construction site.
In addition the concourse will be designed for a heavier load than required in service so that the rough concourse can work as the crash deck.

Criteria	Ranking
Cost	H
Construction duration	H
Safety	H
Project risk	M
Other notes	N/A

2.2.3 Temporary construction bridge

The construction method described in the Tenix report required a temporary construction bridge to be supplied, erected and then later dismantled all of which is both costly and time consuming. BLLC and the design team reviewed the options and have developed a method of design and construction that removes the need for a temporary construction bridge. The acquired site on Little Eveleigh Street will be part of that method.

Criteria	Ranking
Cost	M
Construction duration	M
Safety	M
Project risk	L
Other notes	N/A

2.2.4 Temporary control rooms on platforms

The construction method described in the Tenix report required a number of temporary control rooms on the platforms. In addition the calculations are based on 10 control rooms where only a maximum of 6 is ever needed. BLLC and the design team reviewed the options and have developed a method of design and construction that removes the need for temporary control rooms. (Please refer to appendix C – Station control rooms)

Criteria	Ranking
Cost	H
Construction duration	H
Safety	L
Project risk	L
Other notes	Note 2

Note 2: Reduction in the work required by RailCorp resources.

2.2.5 Type of concourse construction

BLLC and the design team reviewed many options for the type of concourse construction with the aim of reducing construction time, reducing construction cost, maintaining the quality and maintainability of the final product and not requiring any temporary crash decks or bridges. (Please refer to appendix I).

This review confirmed that a pre-cast deck system would achieve all of the above.

Criteria	Ranking
Cost	H
Construction duration	H
Safety	M
Project risk	L
Other notes	N/A

2.2.6 Use of unused southern rail tunnel

BLLC and the design team reviewed the existing constraint associated with the existing unused southern rail tunnel. The current structural concept design(Connell Wagner) made the assumption that the tunnel could be used for foundations. RailCorp have now confirmed that this tunnel is developable land and thus is not required/ not in use.

Structural elements for the development works can pass through the tunnel, which reduces the extent of foundation works required. (Please refer to appendix K)

Criteria	Ranking
Cost	L
Construction duration	L
Safety	N/A
Project risk	L
Other notes	N/A

2.2.7 Effect of metro west exclusion zone

The metro west exclusion zone is an additional constraint to the concept design. The station redevelopment will require works over this metro west exclusion zone. The team investigated different

options of designing foundations within the exclusion zone subject to a RailCorp waiver. (Please refer to appendix N)

It is critical that RailCorp progresses negotiations to allow footings to be placed in this exclusion zone.

Criteria	Ranking
Cost	M
Construction duration	L
Safety	L
Project risk	L
Other notes	Note 10

Note 10: Foundations may pose constraints on Metro west design (waiver may be unacceptable to RailCorp in the first instance).

2.2.8 Extent of Strengthening works on existing platform 11/12

The current concept design (Jackson Teece) required strengthening works to existing structures on platforms 11/12. The design team has looked into options to avoid these works as these are very costly.

The draft revised concept design and associated proposed redevelopment does not require these works to be undertaken. (Please refer to appendix M: Arup sketch SK122)

Criteria	Ranking
Cost	M
Construction duration	M
Safety	H
Project risk	M
Other notes	N/A

2.2.9 Stair construction

The current concept design (Jackson Teece) suggested concrete stairs and support structure.
The design team has confirmed that pre-cast concrete treads on steel supports are acceptable.

Criteria	Ranking
Cost	M
Construction duration	M
Safety	M
Project risk	L
Other notes	N/A

2.3 Detailed items – Design

The following VE items were raised to improve several design related issues.

2.3.1 Impact on OHW and OHW structures/ Concourse alignment

The preferred option C resulted in significant impact on the Overhead Wires (OHW) and OHW structures. Besides the fact that reconfiguring the OHW has major impact on costs it also has a major impact on scarce RailCorp resources. In the previous reporting it was recommended to look into raising the concourse above the OHW structures to save costs and resources needed. (Please refer to Appendix B - sketch SK_03A optionC OHWS impact)

The initial proposal to raise the concourse above the OHW structures resulted in issues associated with vertical transport and accessibility of the station concourse. In addition the extended vertical transportation elements clashed with the OHW structures. (Please refer to Appendix B - sketches SK_04 long section concourse height & SK_05 cross section concourse height)

The design team have looked to reposition the concourse in a way that would have the least impact on OHW and OHW structures. This resulted in a revised layout of the concourse, perpendicular to the railway tracks and connected to the new available land on the Western side of the tracks. This new position and layout will largely reduce the extent of OHW works required.

Criteria	Ranking
Cost	H
Construction duration	H
Safety	H
Project risk	H
Other notes	Note 1

Note 1: Reduction in the work required by RailCorp resources.

2.3.2 New control rooms on platforms

The Jackson Teece concept design suggested 10 new control rooms in new locations on all platforms. This is both costly and a time consuming construction activity. In addition only 6 control rooms are needed instead of 10.
The key issue in moving and replacing the control rooms is the large amount of services to the control rooms. If the existing locations can be used (even back to back with existing locations) this will significantly reduce the costs.

BLLC and the design team reviewed the options and have developed a method of design and construction that allows for the majority of the control rooms to have either a new fit-out, be constructed at the existing locations (platform 2/3 and 10) or back to back at the existing locations, reducing the project cost and duration. (Please refer to appendix C – station control rooms)

Criteria	Ranking
Cost	H
Construction duration	H
Safety	L
Project risk	L
Other notes	Note 3

Note 3: Reduction in the work required by RailCorp

2.3.3 Platform level raising

The Jackson Teece concept design suggested that construction of new platform coping edges was required. This is a time consuming, expensive process with significant risks to RailCorp particularly operational risks.

BLLC and the design team have reviewed the options where platform edge can be retained by lowering tracks instead for level access and lowering internal platform. (Please refer to Sketch SK_07_adjust platform level and appendix D) It was shown that renovation of the existing edges can be undertaken in the majority of cases. This will reduce time, cost and risk while providing a new surface (pavers or tiles) to the platform edge.

Criteria	Ranking
Cost	H
Construction duration	H
Safety	H
Project risk	H
Other notes	N/A

2.3.4 New canopy structures

The Jackson Teece concept design notes new canopy structures to be installed.
BLLC and the design team reviewed the extent of new works required including reviewing options for some of the supper-structure and existing footings to be re-used. The review found that although a small number could be re-used that this would impact the platform area and architectural outcome. (please refer to appendix E)

The vertical transport from the new concourse will in any case impact on existing roofs and structure. In addition the roofs slope to the edge currently making it difficult to drain them discretely which also results in safety issues when cleaning and maintaining gutters.

As canopies are a relatively small cost it is suggested that this item be explored in detail once the position/alignment of the concourse, retention of heritage buildings are resolved. The first step would be a detailed study of the status of the existing structures.

Criteria	Ranking
Cost	M
Construction duration	H
Safety	M
Project risk	L
Other notes	Note 4

Note 4: Re-use of existing awnings will impact on the architectural outcomes.

2.3.5 Extent of demolition works

The Jackson Teece concept design detailed a large extent of demolition works on the platforms. BLLC and the design team reviewed the possibilities of retaining more heritage buildings than assumed for in the current concept design as well as retaining the stairs from the existing concourse.

The extent of demolition works required to meet the design outcomes has been reviewed and a significant extent of previously detailed demolition works is not necessarily required. However, the main issue that needs to be addressed is compliance to RailCorp standards in relation to platform clearances next to heritage buildings and stairs. (Please refer to appendix G)

Criteria	Ranking
Cost	L
Construction duration	L
Safety	L
Project risk	L
Other notes	Note 5

Note 5: Reduction in the work required by RailCorp resources, increased extent of heritage items retained and may impact on platform area and DDA requirements.

2.3.6 Location of Main offices

In the current concept design (Jackson Teece) the station offices and facilities are located on the station concourse. The design team reviewed a number of locations for the station offices and associated back-of-house areas to avoid major plumbing works and associated maintenance issues when positioned on the concourse.

Possible options included the existing buildings on platform 1, on the concourse or on the Eastern side adjacent to the concourse/main entrance. This review confirmed that locating these facilities on the Eastern side adjacent to the concourse/main entrance (not over the platforms) is both cost effective and acceptable to RailCorp. (Please refer to appendix H)

Criteria	Ranking
Cost	M
Construction duration	M
Safety	L
Project risk	L
Other notes	N/A

2.3.7 Concourse supports on platforms

BLLC and the design team reviewed options to limit the extent of construction works required on the platforms and to increase the available platform area. Appendix J shows the different options.

Criteria	Ranking
Cost	M
Construction duration	M
Safety	L
Project risk	L
Other notes	Note 6

Note 6: Increased platform area

2.3.8 Extent of supports on platforms

In the current concept design (Jackson Teece) the concourse requires support on every platform. BLLC and the design team reviewed options to limit the number of concourse support on platforms; avoid foundation / support on every platform to reduce collision impact.

The review confirmed that the concourse structure could be designed in a way where supports are only required on every second platform. However, deeper and heavier structural elements for the concourse deck are needed and larger beams will push the concourse level higher by approx 750mm and increase lifting weights. (Please refer to appendix I – Concourse structure)

The impact of use of deeper precast (super-T) beams will need to be reviewed by both cost and constructability consultant. For spans of 35 m a 1500 mm deep Super 'T' will be required. Weight is approx 55 tonnes (as compared to a 14 m span, 750 mm deep Super 'T' at 17 tonnes)

Criteria	Ranking
Cost	L
Construction duration	M
Safety	L
Project risk	L
Other notes	Note 7

Note 7: Increased concourse height.

2.3.9 Unpaid pedestrian link over train lines

The current concept design (Jackson Teece) accommodates an unpaid pedestrian link over the rail lines in line with the concourse but as a separate structure. BLLC and the design team reviewed various options for the unpaid pedestrian link in order to create a more efficient structural approach to save construction time and costs. (Please refer to appendix L – Unpaid pedestrian link options)

The review confirmed that a number of options are available. Each option has different advantages and disadvantages with regards to operations. One option where the design team have looked at in more depth is to stack the unpaid link over the top of the paid concourse. This option, together with the other options, need to be reviewed by the cost and constructability consultant. Following their review RailCorp should be able to identify a preferred option.

Criteria	Ranking
Cost	L
Construction duration	M
Safety	M
Project risk	L
Other notes	Note 8

Note 8: Unpaid link over the top of concourse will need less supports on platform and reduce strain on possessions. However elevated link will need longer ramps and lifts and thought must be put into safety and security of pedestrians after hours.

2.4 Detailed items – Procurement strategy

The following VE items were raised in relation to procurement strategies.

2.4.1 Station ticket gates

The previous cost plan (Tenix, 2007) allowed for the full cost of upgrading the ticket gates to be included as part of the capital expenditure for the redevelopment of Redfern station. The cost of upgrading the existing number of gates could be reallocated to the maintenance budget. This leaves the additional gates as part of the Capex for the redevelopment of the station.

Criteria	Ranking
Cost	H
Construction duration	N/A
Safety	N/A
Project risk	N/A
Other notes	N/A

2.4.2 New substations

The Jackson Teece concept design detailed new transformers and associated works. BLLC and the design team reviewed the load on the existing transformers and the increase demand from the proposed redevelopment. This review confirmed that the existing transformers are adequate for the load of the post developed station and as such do not require replacement. (Please refer to appendix F - *Memo Electrical Demand 16/02/09*)

Criteria	Ranking
Cost	H
Construction duration	N/A
Safety	N/A
Project risk	N/A
Other notes	N/A

2.4.3 Extent of commercial development works required by RailCorp

The extent of works required to be undertaken by RailCorp to allow the future redevelopment have been extensively reviewed. BLLC and the design team focused on options where works required by RailCorp to enable the commercial development would be minimised.

In a first draft of the revised concept design it shows that very limited works are being required to be undertaken by RailCorp, thus saving costs for RailCorp. In addition the team looked at creating a floor plate for the commercial development which would give the highest results in attracting tenants. (Please refer to appendix M)

Criteria	Ranking
Cost	H
Construction duration	M
Safety	L
Project risk	L
Other notes	Note 9

Note 9: Creates a more significant station entrance and public domain as well as an efficient building floor plate. In addition staging of the construction between station and commercial development is easier.

2.4.4 Carpark and retail buildings

The extent of works required to be undertaken by RailCorp to allow the future redevelopment have been extensively reviewed. The draft revised concept design now allows for very limited works being required to be undertaken by RailCorp, thus saving costs for RailCorp. A further advantage is the result of a more desirable building floor plate. (Please refer to appendix M: Arup sketch SK122)

Criteria	Ranking
Cost	M
Construction duration	M
Safety	M
Project risk	L
Other notes	Note 11

Note 11: Staged construction easier.

2.5 Summary value engineering items

In the table below an overview of the value engineering items and their rankings is shown.

#	Value engineering item	Cost	Constr. duration	Safety	Project risk
Construction items					
1	Possession timetable	H	H	H	H
2	Temporary crash deck	H	H	H	M
3	Temporary construction bridge	M	M	M	L
4	Temporary control rooms on platforms	H	H	L	L
5	Type of concourse construction	H	H	M	L
6	Use of unused southern rail tunnel	L	L	N/A	L
7	Effect of Metro West exclusion zone	M	L	L	L
8	Extent of strengthening works on existing platform 11/12	M	M	H	M
9	Stair construction	M	M	M	L
Design items					
10	Impact on OHW (structures) / Concourse alignment	H	H	H	H
11	New control rooms on platforms	H	H	L	L
12	Platform level raising	H	H	H	H
13	New canopy structures	M	H	M	L
14	Extent of demolition works	L	L	L	L
15	Location of main offices	M	M	L	L
16	Concourse supports on platforms	M	M	L	L
17	Extent of supports on platforms	L	M	L	L
18	Unpaid pedestrian link over train lines	L	M	L	L
Procurement strategy items					
19	Station ticket gates	H	N/A	N/A	N/A
20	New substations	H	N/A	N/A	N/A
21	Extent of commercial development works required by RailCorp	H	M	L	L
22	Carpark and retail buildings	M	M	M	L

3. Conclusion & recommendation

This initial value engineering study and associated workshops was held by BLLC with the aim for the design team to incorporate these value engineering principles into the revised concept designs to achieve the maximum value for RailCorp.

3.1 Conclusion

The value engineering process has resulted in 22 items where possibly cost reductions, shortened construction durations, enhanced building value, enhanced customer experience, increased safety of construction and maintenance works and increased value to RailCorp could be achieved.

Incorporating these value engineering items into the revised concept design for the Redfern Station Redevelopment will significantly add value to RailCorp. Referring to the ranking of the items the proposed possession timetable has the highest impact on the construction method, the concourse alignment has the highest impact on the design and the car park, retail buildings and enabling works have the highest impact on procurement strategy or staging.

3.2 Recommendation

It is recommended that all 22 items need further reviewing by the cost and constructability consultant to provide further information relating to potential cost savings and reduction in construction duration. After that is completed the last two phases of the value engineering process could be completed: phase 4 – Proposal and Phase 5 – Final report.

Appendix A – Proposed possession timetable

In the attached minutes a preferred possession timetable is outlined:

Meeting Minutes

RPMM Document ID: RPMM-100-MM-0001; Release Date: 22 May 2008

Redfern Station Redevelopment

Meeting 2

Coordinator/Chair	Rex Gunton		
Date and Time	12 November 2008		
Location	18 Lee Street, Level 4		
Next Meeting	Tbc		
Meeting Objective	Agree possessions schedule for Redfern Station Redevelopment		
Attendees			
Rex Gunton (RG)	Ray Beasley (RB)	Melissa Iverach (MI)	Andrew Quarmby (AQ)
Andrew Quarmby (AQ)	Karlijn Klawer (KK)	Serge Chetner (SC)	
Invited Guests			
Apologies			

1 Meeting Outcomes

1.1 Review Actions from Previous Meetings

Meeting with Melissa Iverach established.

Availability of the 5 day track possession during Christmas from 2013. Bear in mind that other projects might want to lock in the same possessions…

1.2 Matters Arising

- MI asks RB what is needed to get approval for the proposed possessions regime. RB points out the current situation is that we need CEO approval for these things.
- The impacts of the possessions to the clients and the station are the main item where approvals or declines are based on. MI will investigate the impacts on our proposal.
- Two options will be discussed: one based on standard weekend possessions and one based on the proposed possessions regime. For these two options we need costs & benefits/grieve.
- The number one questions to answer are:
  - Why so long (5 days over Christmas or 26 weeks for tracks 1 & 10)?
  - Why this period (Christmas)?
  - What is the scope?
  - What are the long term benefits?

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- Why knock down all the buildings on the platforms prior to construction?

- MI agrees to work together on this proposal to get a clear understanding of the impacts and costs, both positive and negative and therefore agrees to our approach.

1.3 Discussion

- Assumed during the meeting, as a starting point, is that demolition works will commence circa June 2011 followed by actual construction commencing circa February 2012.
- Below possessions proposal will be detailed out further by AQ for MI and RB to be able to understand the impacts involved:
  - Config 3 (platforms 1-4) > 5 day possession (track & platform)
  - Config 1A > 5 day possession (track & platform)
  - Platform 10 > closed for a long period of time (platform only)
  - Platform 1 > closed for a long period of time (platform only)
  - Config 4 > to get spoil train in while demolishing buildings on platforms.

  NB1: None of these possessions need to happen simultaneously

  NB2: weekend possessions will be optimised in addition
- Ray points out to take into account that all bussing costs will have to be picked up.

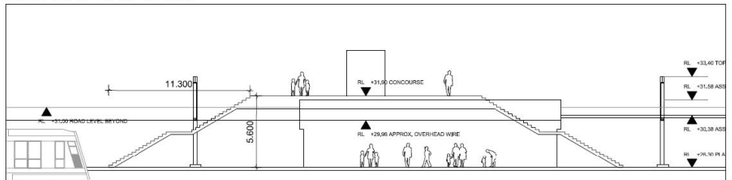
1.4 Key Decisions

- Ongoing contact and communication with the possessions team will move this project forward gaining an understanding of impacts and costs involved.
- Additional meetings will be required once the engineering- & architectural consultants are on board, possibly with the attendance of people like Dave Spiteri.

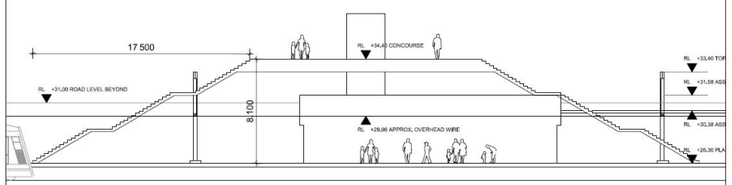
Appendix B – Impact on OHW structure

The following sketches show the impact on the OHW structures in relation to the alignment of the concourse.

The following sketches show the impact on accessibility and vertical transport by raising the concourse above the OHW structures.

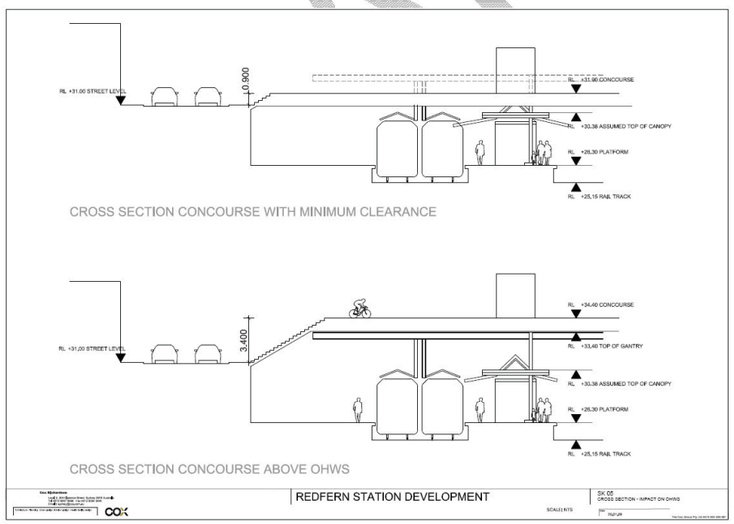


LONG SECTION (PLATFORM 8&9) CONCOURSE WITH MINIMUM CLEARANCE



LONG SECTION (PLATFORM 8&9) CONCOURSE ABOVE OHWS

REDFERN STATION DEVELOPMENT | SK 04 LONG SECTION - IMPACT ON OHWS | SCALES NTS



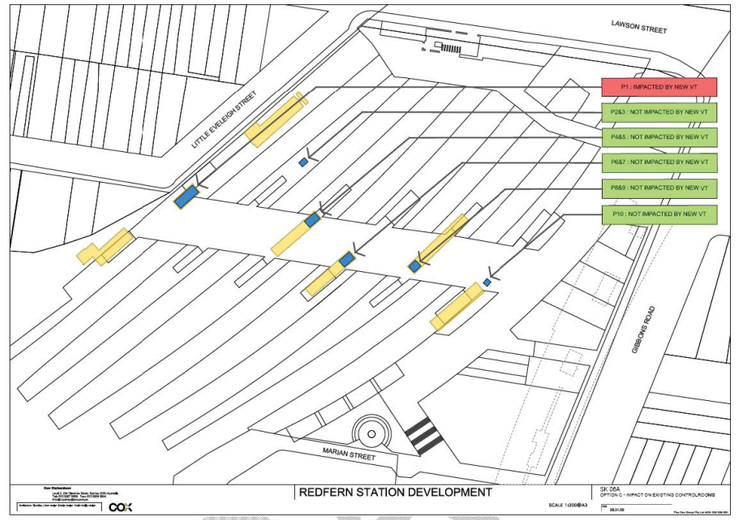
CROSS SECTION CONCOURSE WITH MINIMUM CLEARANCE

CROSS SECTION CONCOURSE ABOVE OHWS

REDFERN STATION DEVELOPMENT | SK 05 CROSS SECTION - IMPACT ON OHWS | SCALES NTS

Appendix C – Control rooms

The following sketches show the impact on the control rooms in relation to the alignment of the concourse.



Appendix D – Platform level raising

The following sketches show the RailCorp's requirements with regards to platform level heights in relation to train access etc. and the extend of platform level raising needed to comply.

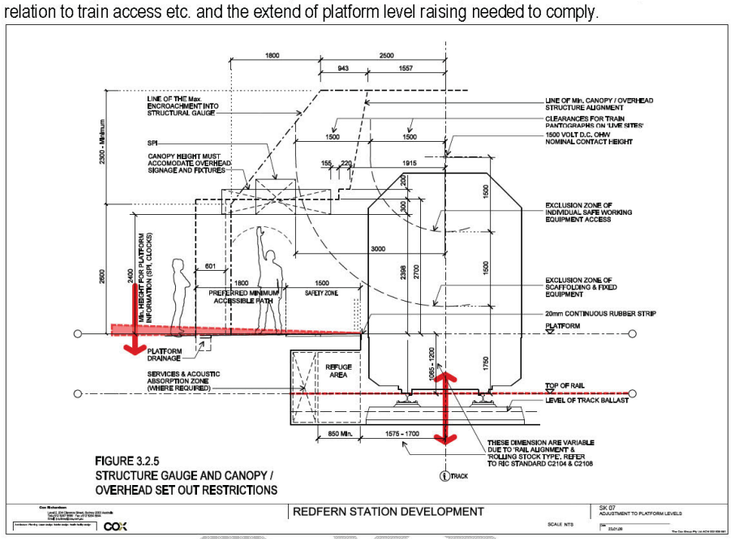
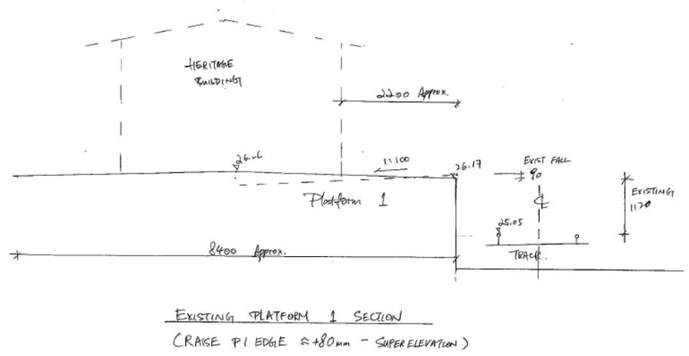
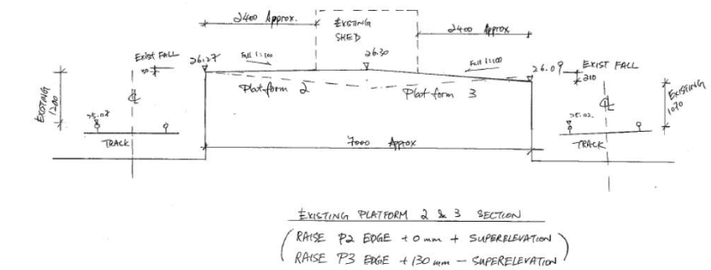


FIGURE 3.2.5
STRUCTURE GAUGE AND CANOPY / OVERHEAD SET OUT RESTRICTIONS

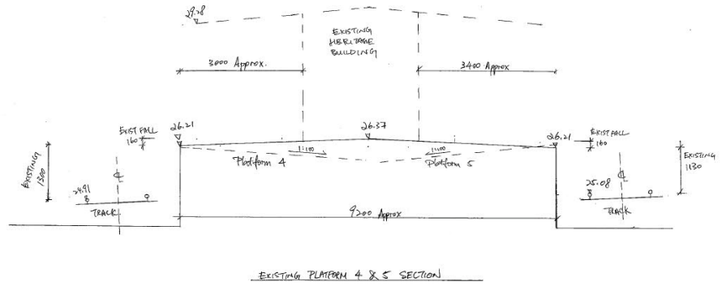
Below follow ARUP sketches – SK105 – SK110:



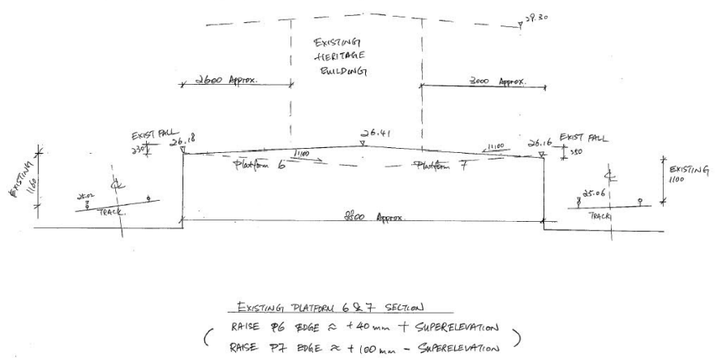
ARUP sketch – SK105



ARUP sketch – SK106



ARUP sketch – SK107



ARUP sketch – SK108

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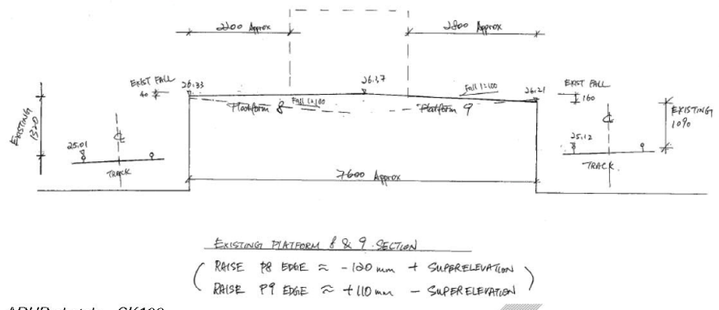
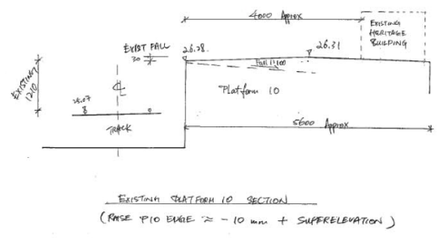
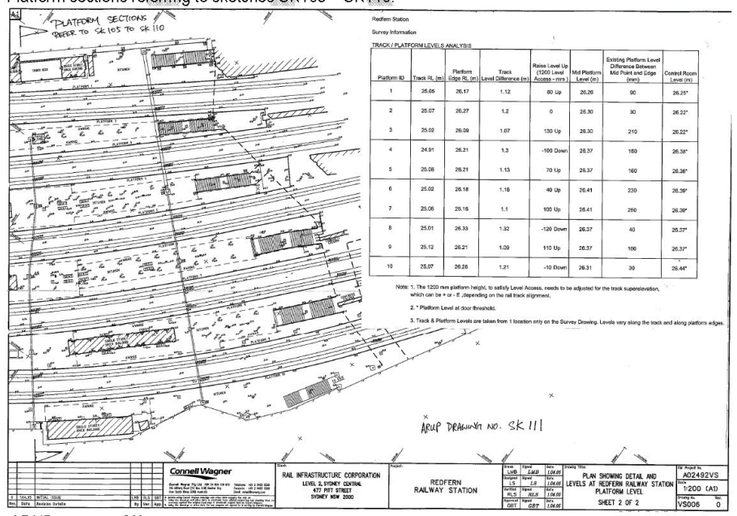


ARUP sketch – SK109



ARUP sketch – SK110

Platform sections referring to sketches SK105 – SK110:



Platform ID	Track RL (m)	Platform Edge RL (m)	Level	Track Difference (m)	Raise Level Up (1200 Level Access - mm)	Mid Platform Level (m)	Existing Platform Level Difference Between Mid Point and Edge (mm)	Control Room Level (m)
1	25.66	26.17		1.12	80 Up	26.26	90	26.25*
2	25.67	26.27		1.2	0	26.30	30	26.22*
3	25.02	26.09		1.07	130 Up	26.30	210	26.22*
4	24.91	26.21		1.3	-100 Down	26.37	160	26.38*
5	25.08	26.21		1.13	70 Up	26.37	160	26.38*
6	25.02	26.18		1.16	40 Up	26.41	230	26.39*
7	25.06	26.16		1.1	100 Up	26.41	200	26.39*
8	25.01	26.33		1.32	-120 Down	26.37	40	26.37*
9	25.12	26.21		1.09	110 Up	26.37	100	26.37*
10	25.07	26.26		1.21	-10 Down	26.31	30	26.44*

Note: 1. The 1200 mm platform height, to satisfy Level Access, needs to be adjusted for the track superelevation, which can be + or - E ,depending on the rail track alignment.

2. * Platform Level at door thresholds.

3. Track & Platform Levels are taken from 1 location only on the Survey Drawing. Levels vary along the track and along platform edges.

ARUP sketch – SK111

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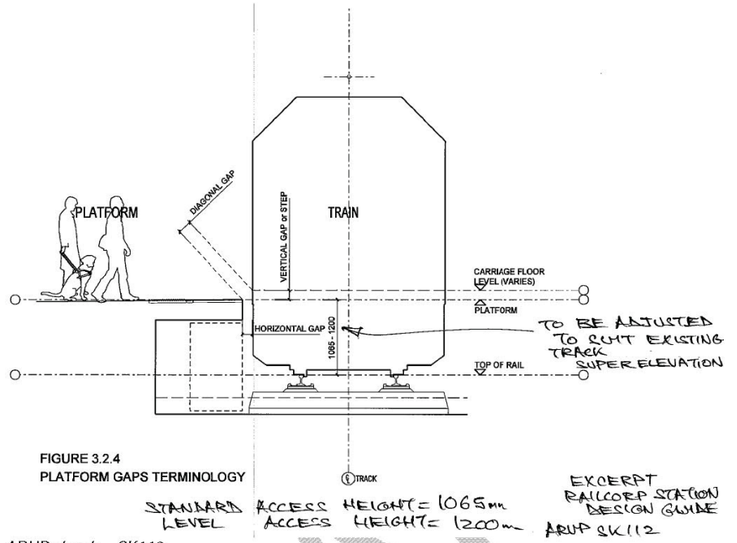

FIGURE 3.2.4
PLATFORM GAPS TERMINOLOGY

ARUP sketch – SK112

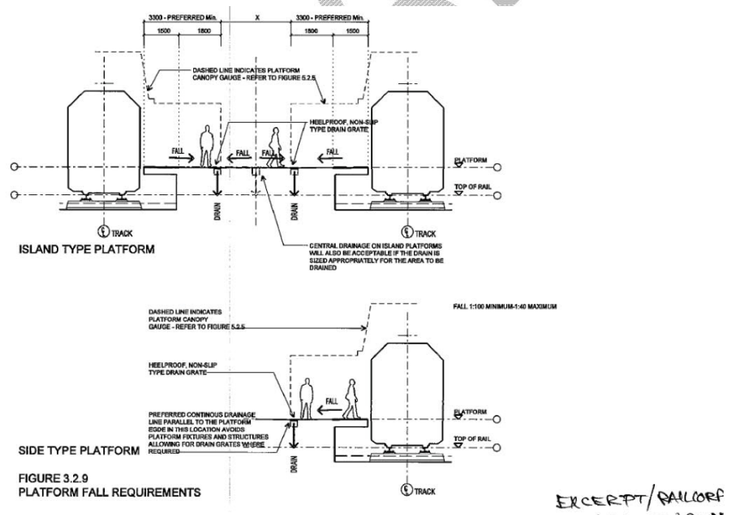

FIGURE 3.2.9
PLATFORM FALL REQUIREMENTS

ARUP sketch – SK114

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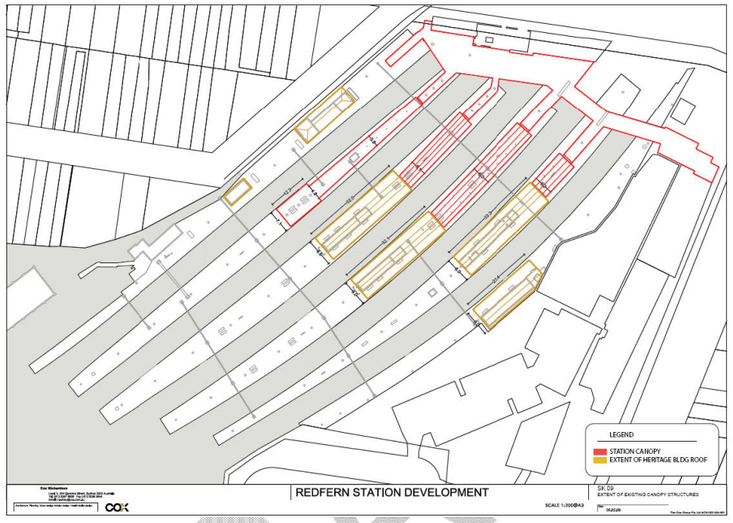
Appendix E – Canopy layouts

The following sketches show the current canopy layout and structures.



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Appendix F – Memo electrical demand

ARUP

Memorandum

To	Karlijn Klawer, Bovis Lend Lease Consulting	Reference number	206113/00/SEBM
cc		File reference	
From	Mike Cook / Simon Makeham	Date	16 February 2009
Subject	Redfern Station Refurbishment - Electrical Demand		

Karlijn,

As requested, we have undertaken a review of the impact of the refurbishment works at Redfern Station on the existing electrical supply.

The review was based on the following:

1. The information contained in the Connell Wagner report "Redfern Station Upgrade – Preliminary Services Recommendations – Rev. 3" dated 15/03/07
2. The refurbishment will consist of 6 new Machine-Room-Less Lifts (MRL) and approximately 3000m² additional concourse area
3. The possible inclusion of escalators providing access from the Concourse to the platforms – equates to 12 new escalators.

Existing Loads

From Connell Wagner's report, the station is supplied by 2 off 500kVA transformers, one loaded at 46% of design capacity and the other 84% of design capacity. The design capacity for the transformers is that the maximum load per transformer is to be 50% of the transformer rating, such that if one transformer fails, the entire station load can be supplied from the remaining transformer. The following table summarises the existing demand:

Transformer	Rating	Design Capacity	Existing Transformer Demand (@ March '07)		Spare Capacity
	kVA	kVA	% Design Cap.	kVA	kVA
1	500	250	46%	115	135
2	500	250	84%	210	40

Additional Lift and Light Load

To determine the additional demand due to the lift installation, the demand of each lift was based on demands for similar size of lifts as advised on recent projects. From this information, the demand of each lift is approximately 30Amps. Maximum demand was calculated based on Table C2 of AS/NZS3000 – 2007.

The additional maximum demand due to the lifts was calculated as 86kVA.

For additional Concourse lighting load, a basis of 10VA/m² has been used.

The additional maximum demand due to the new Concourse lighting was calculated as 30kVA.

Additional Escalator Load

To determine the additional demand due to the escalators, the demand of each escalator was based on demands for similar size escalators as advised on recent projects. From this information, the demand of each escalator is approximately 36Amps (10 total), with the 2 escalators serving the Illawarra platforms having a

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206113/00/SEBM

Memorandum

16 February 2009

demand of approximately 50Amps (2 total). Maximum demand was calculated based on Table C2 of AS/NZS3000 – 2007.

The additional maximum demand due to the additional escalators was calculated as 201kVA.

Revised Loads & Impacts

Based on the information outlined above, the loading on the existing transformers with lifts and lighting changes only is summarised as per the following table.

Without Escalators – Lifts and Lighting Only

Transformer	Existing Load	Spare Design Capacity (existing)	Additional Load	New Transformer Load	Spare Capacity
	kVA	kVA	kVA	kVA	kVA
1	115	135	116	231	19
2	210	40	0	210	40

Based on the information in Connell Wagner's report and the details as stated above, the existing transformers would have sufficient capacity for the additional load based on our assessment of the additional lift and lighting demand. Should there have been any upgrades or changes in the 2 years since Connell's report, this has not been captured in this analysis. Clarification on any additional loads on the transformers at the station over the last 2 years should be obtained.

Should escalators be installed, the existing capacity of the transformers will be exceeded, requiring an upgrade as per Connell's report. The preferred option in this report was for the upgrade of the existing 500kVA transformers with 750kVA transformers, which from preliminary review would appear the most satisfactory option.

Regards

Mike Cook / Simon Makeham

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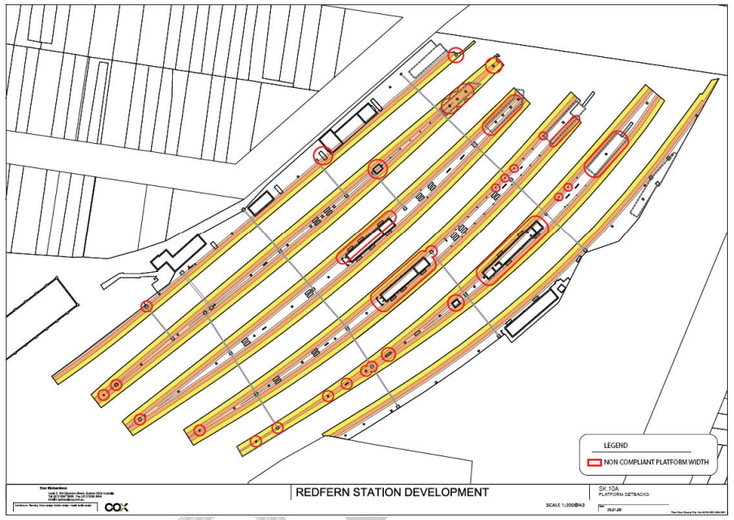
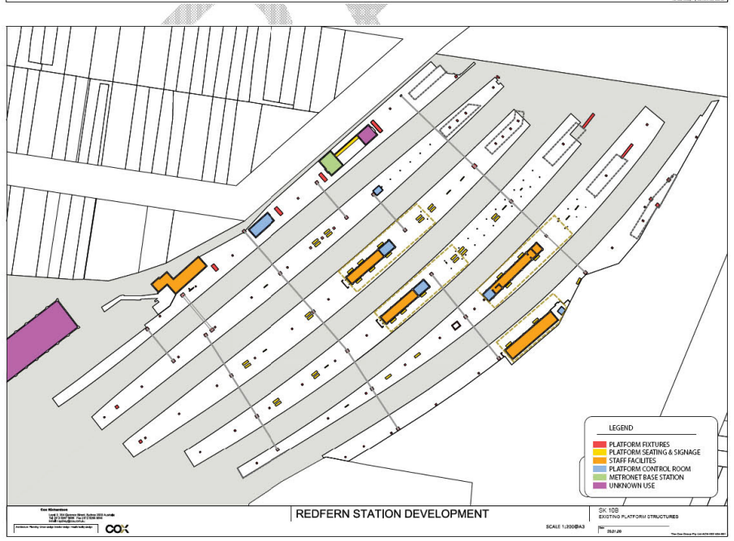
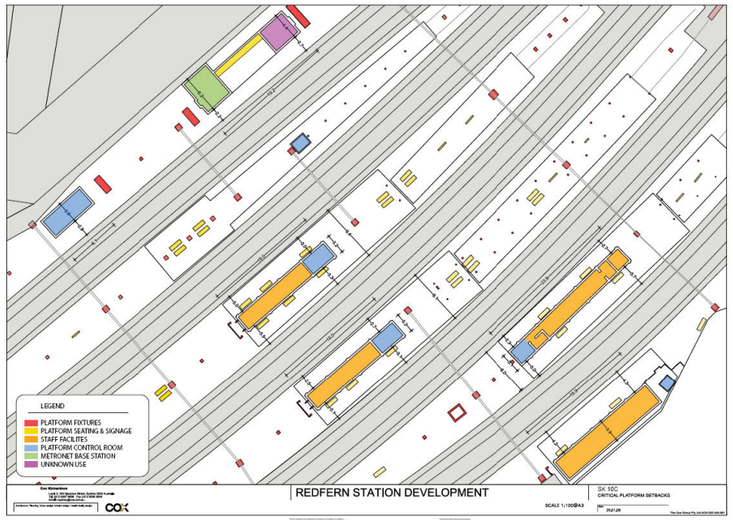
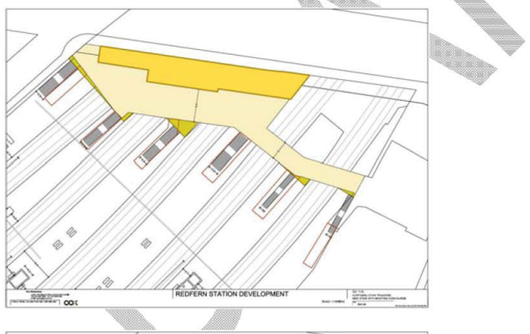
Appendix G – Demolition works

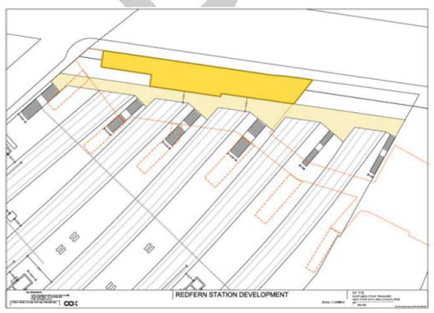
The following sketches show the extend of critical platform setbacks caused by "obstacles" on the platforms such as heritage buildings, staircases and other structures.





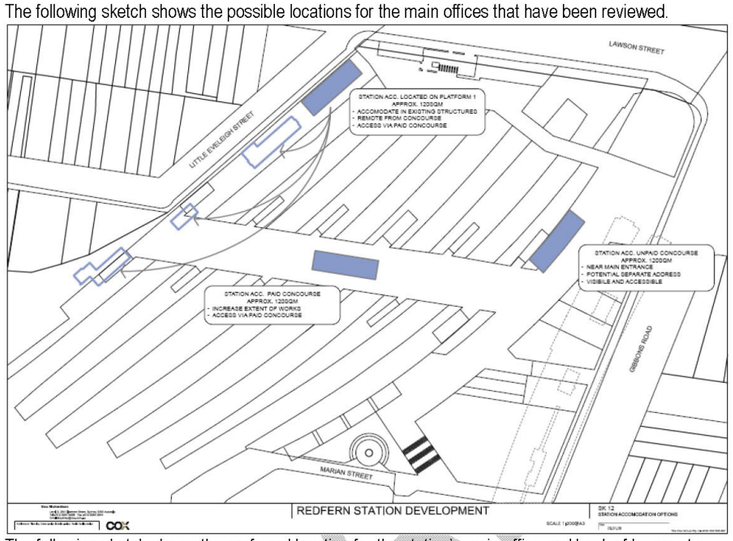




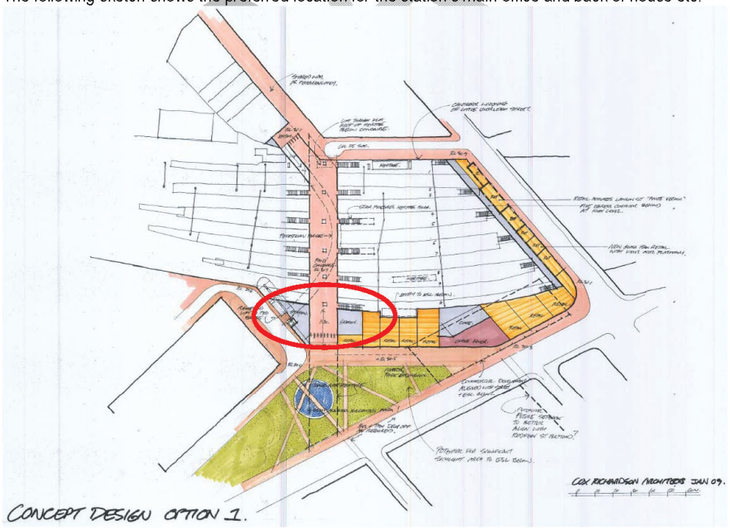


Appendix H – Location of main offices

The following sketch shows the possible locations for the main offices that have been reviewed.



The following sketch shows the preferred location for the station's main office and back of house etc.



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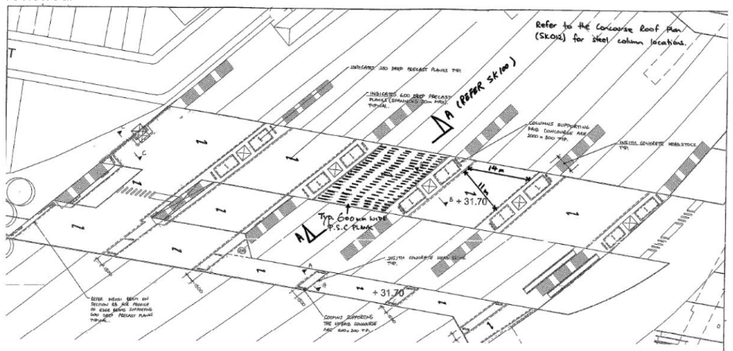
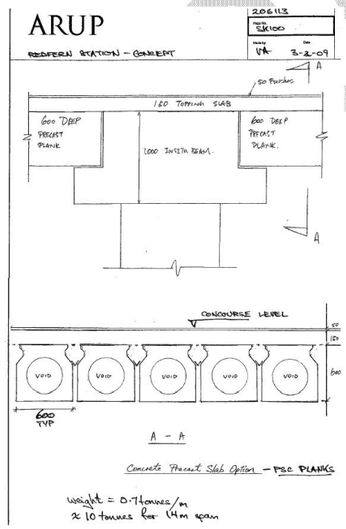
Appendix I – Concourse construction

The following sketches show some structural principals for the concourse construction which have been reviewed.





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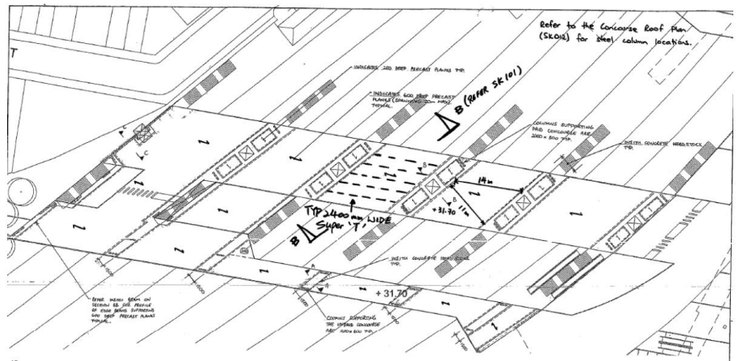
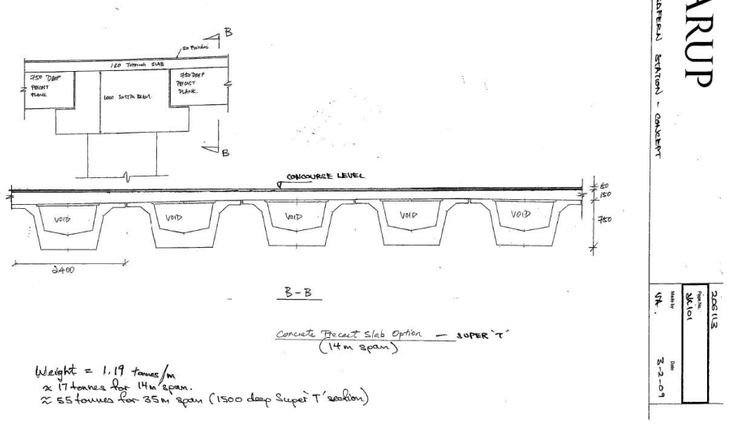
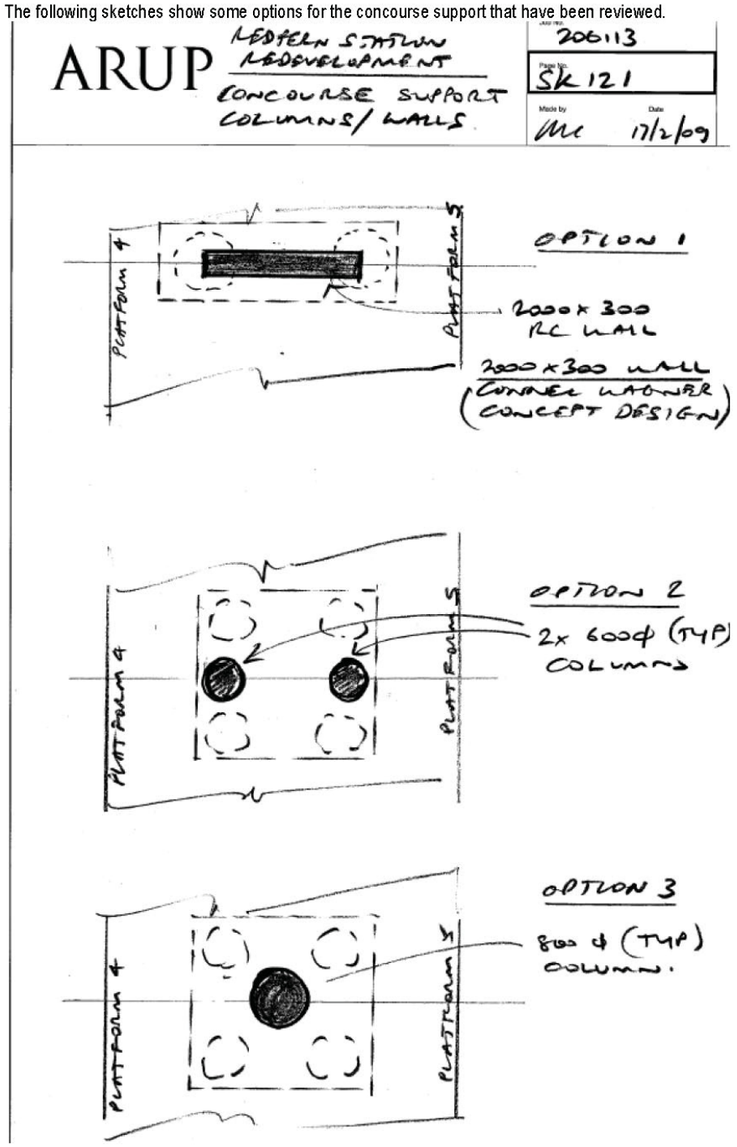


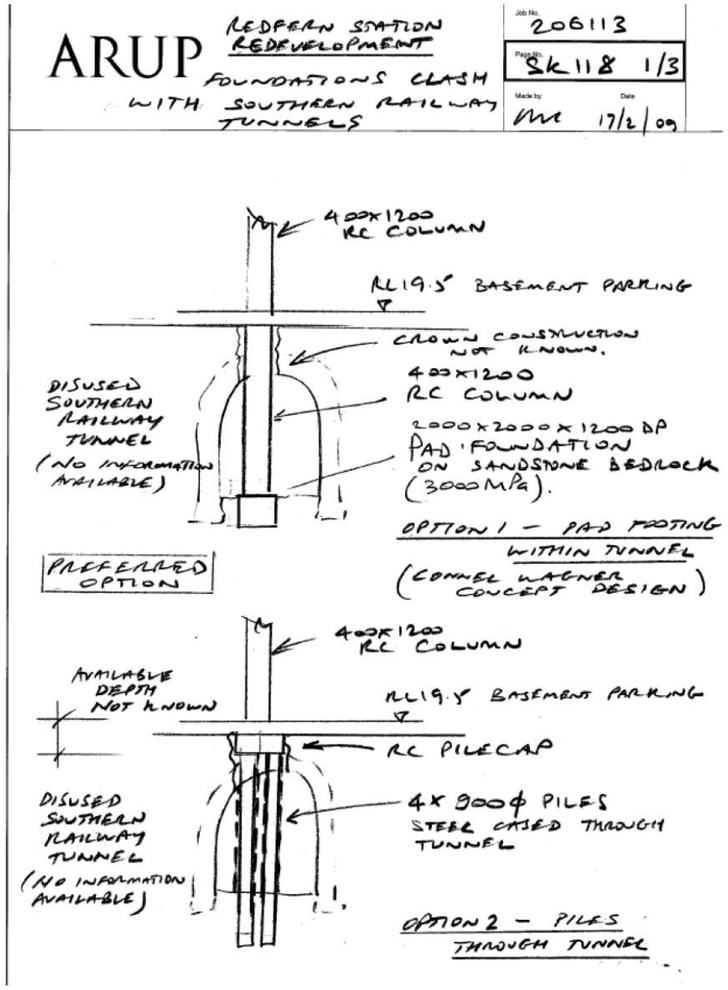


Appendix J – Concourse supports

The following sketches show some options for the concourse support that have been reviewed.



Appendix K – Southern railway constraint



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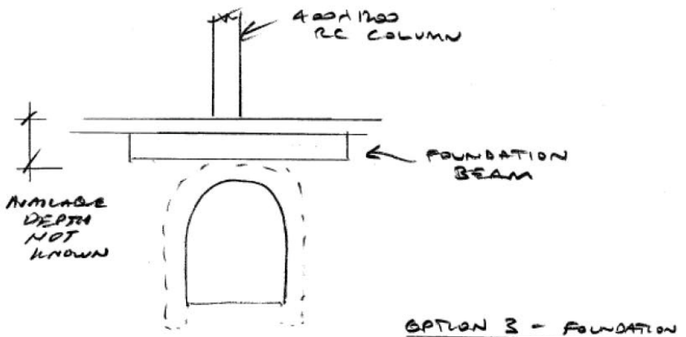
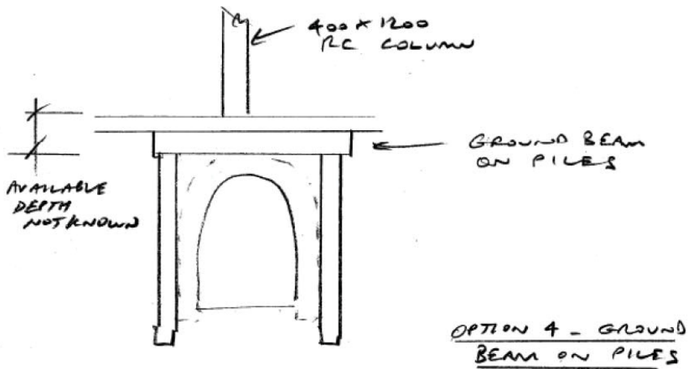
REDFERN STATION REDEVELOPMENT
FOUNDATIONS CLASH WITH SOUTHERN RAILWAY TUNNELS

Job No. 206113
Page No. SK118 2/3
Made by MC Date 17/2/09



OPTION 3 - FOUNDATION BEAM



OPTION 4 - GROUND BEAM ON PILES

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REDFERN STATION REDEVELOPMENT
FOUNDATIONS CLASH WITH SOUTHERN RAILWAY TUNNELS

Job No. 206113
Page No. SK118 3/3
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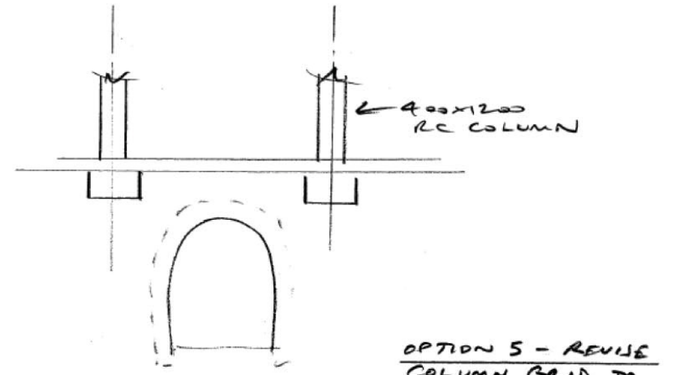
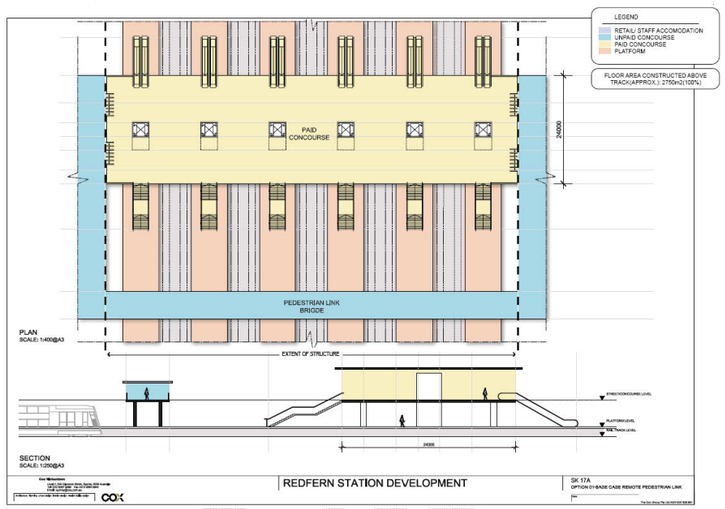
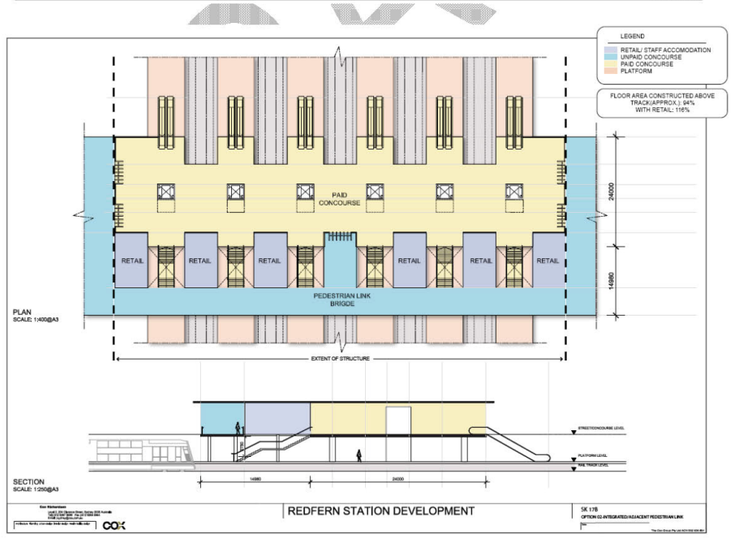


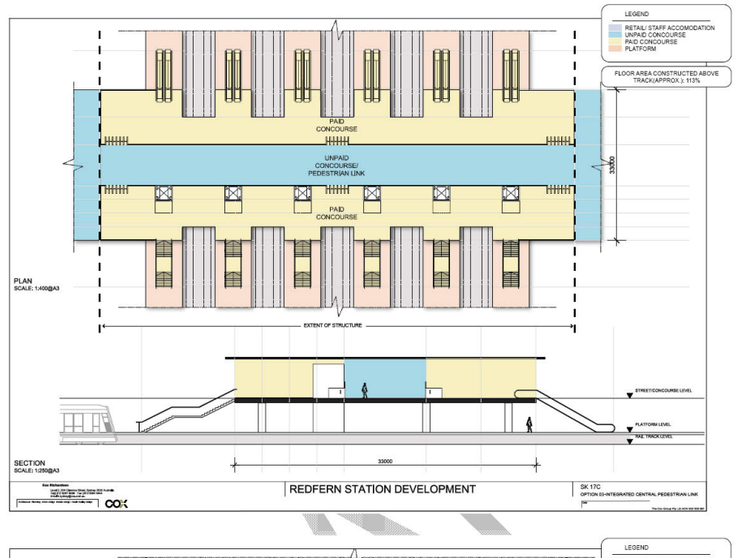
OPTION 5 - REVISE COLUMN GRID TO OFFSET CLEAR OF TUNNEL

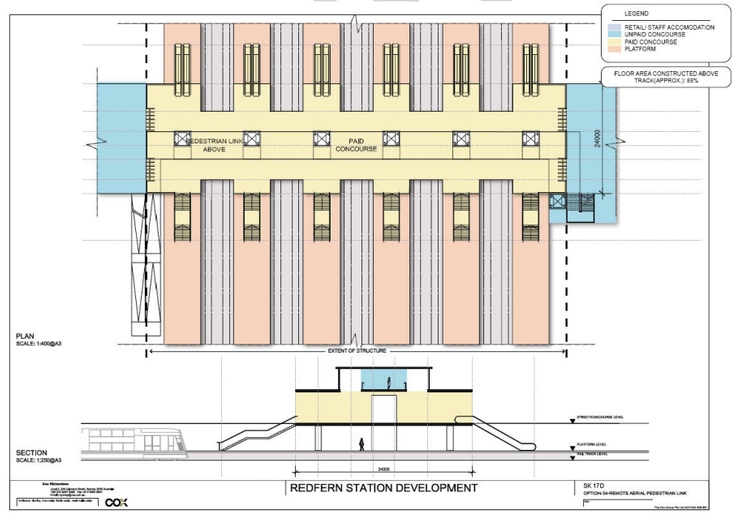
Appendix L – Unpaid pedestrian link options

The following sketches show the different options for locating the unpaid link over the rail corridor in relation to the paid concourse.









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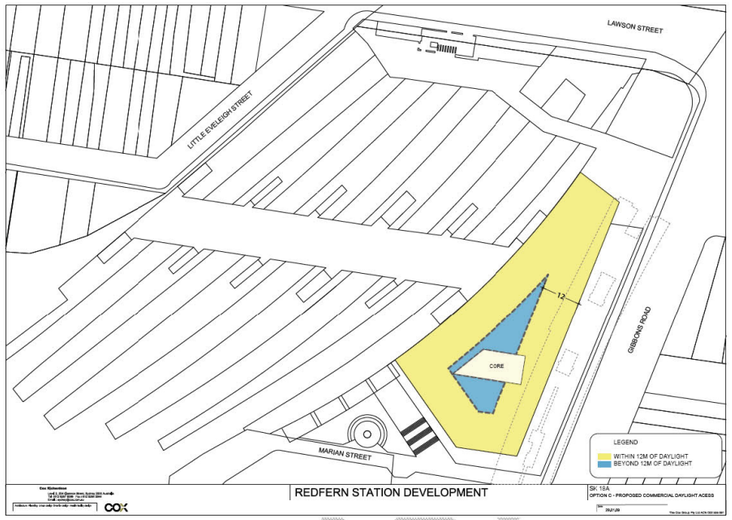
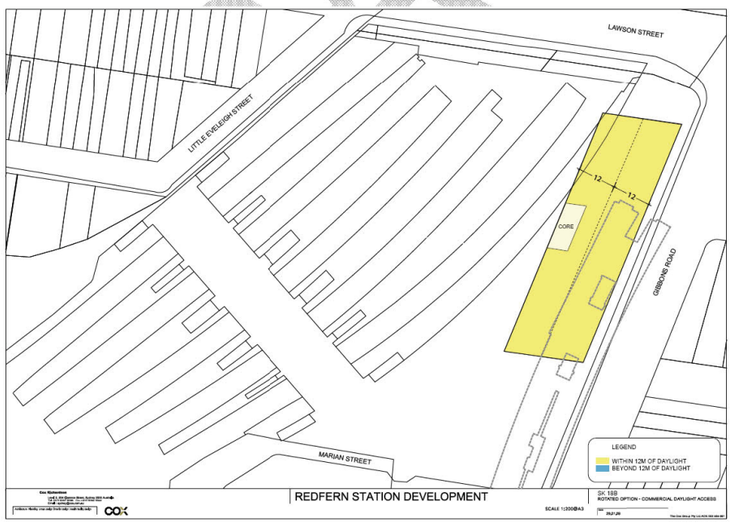
Appendix M – commercial development





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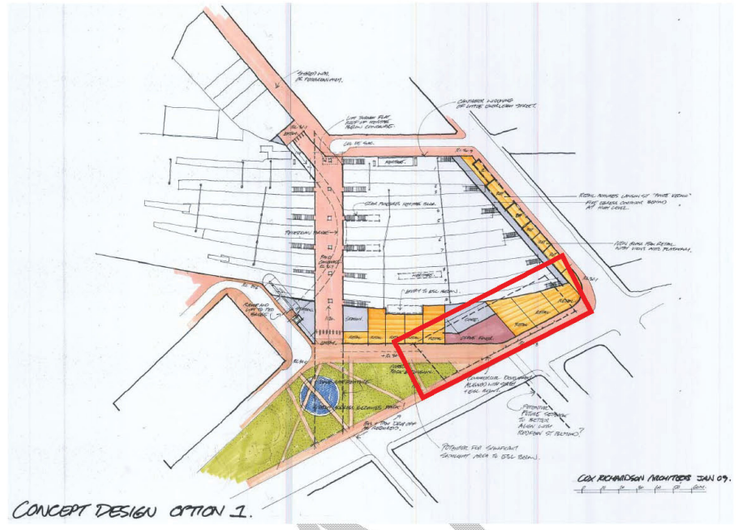
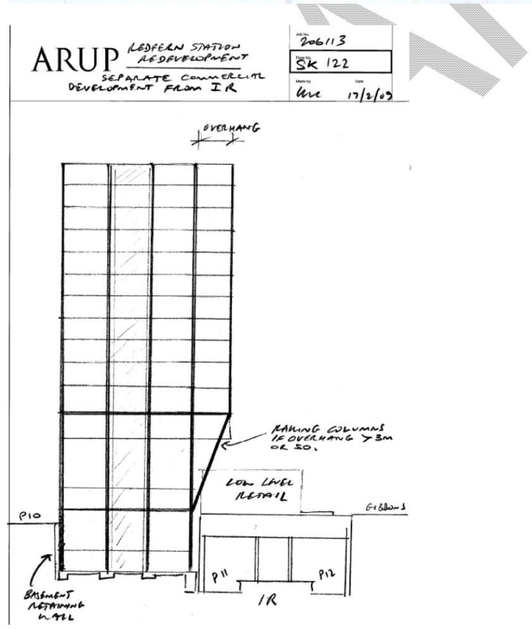
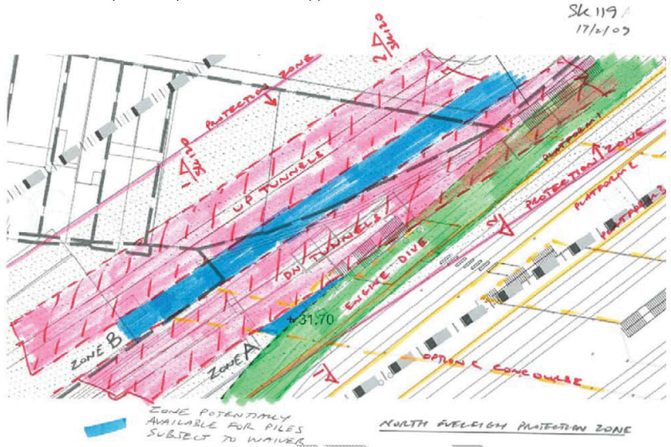
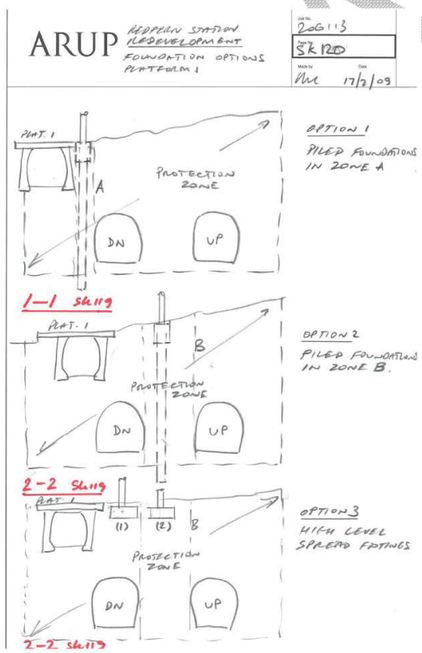




Appendix N – Metro West exclusion zone

The following sketches show the exclusion zone on Little Eveleigh street side of the rail way lines. The sketches show potential positions for the support of the new concourse which in all cases need a waiver





RailCorp

Redfern Station Redevelopment

Revised Concept Design

ARUP

RailCorp

Redfern Station Redevelopment

Revised Concept Design

Crowd Modelling

May 2009

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Job number 206197

ARUP

Document Verification

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Document title	Revised Concept Design		File reference
Document ref	REP/206113/002		

Revision	Date				
Draft 1	9/04/09	Filename	Revised Concept Report Draft.doc		
		Description	Report outline		
			Prepared by	Checked by	Approved by
		Name	Douglas Pickering	Paul Stanley	Paul Stanley
		Signature			
Draft 2	27/04/09	Filename	007-B Revised Concept Design Report_Pedestrian Analysis.doc		
		Description	Updated to Reflect KK comments 23/04/09		
			Prepared by	Checked by	Approved by
		Name	Douglas Pickering	Paul Stanley	Paul Stanley
		Signature			
Draft 3	05/05/09	Filename	007-D Revised Concept Design Report_Pedestrian Analysis.doc		
		Description	Updated to reflect Concept Design changes		
			Prepared by	Checked by	Approved by
		Name	Douglas Pickering	Paul Stanley	Paul Stanley
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document Verification with Document ✓

Contents

Appendices

1 Introduction

This report provides the crowd modelling report for Redfern Station design Redevelopment. Arup has been engaged by RailCorp to progress the concept development planning of Redfern Station to the project definition stage, on the basis of work undertaken by Jackson Teece / Connell Wagner in 2007. The anticipated outcome of the design progression is a refined concept design that can be used as the basis for a business case submission by RailCorp for government funding.

This report summarises the key findings of the peer review report, discusses the principles that have governed the design progression from a crowd modelling perspective and then examined the performance of the concept design.

1.1 Anticipated Future Demand and Operations

RailCorp provided a demand matrix for station entry, exit and interchange movements at 2061 demand levels, as shown on Table 1 below:

Table 1 Redfern Station, 2061 AM Demand Estimates

2061-Emp-2 ECRL-Trips.xls

Redfern	*Base 2051*			DepPla>							
ArrPla	1 (ICR2)	3 (SN)	4 (NS)	5 (CO1)	6 (CI2)	7 (CI1)	8 (CO2)	11 (SE)	12 (ES)	Exit	Total
1 (ICR1)	0	1,988	391	1,432	56	960	4	986	54	160	6,030
3 (SN)	0	0	0	77	0	408	58	168	606	5,950	7,268
4 (NS)	20	0	0	0	0	0	7	0	0	1,938	1,965
5 (CO1)	17	0	0	0	0	0	3	103	465	2,585	3,174
6 (CI2)	0	0	0	0	0	0	0	0	0	708	708
7 (CI1)	54	227	906	0	722	0	8	239	0	5,336	7,491
8 (CO2)	2	0	15	0	0	0	0	0	4	355	377
11 (SE)	11	840	848	710	695	1,038	0	0	0	4,641	8,784
12 (ES)	12	0	19	0	28	0	26	0	0	607	692
Entry	59	1,408	497	209	751	124	474	474	315	0	4,312
Total	175	4,463	2,676	2,428	2,252	2,531	581	1,970	1,444	22,281	40,800

The primary demands inherent within this 2061 matrix are as follows:

- Significant alighting loads from Platform 1, dominated by interchange movements to P3, P5, P7 and P11. The design capacity of P1 will therefore need to cater for largely uni-directional movements.
- P2/3, P4/5 and P6/7 are subject to a significant volume of bi-directional movement, both from interchange movements and station entry and exit demands
- P8/9 is relatively unused with minimal passenger boarding or alighting movements
- P11/12 is subject to the highest alighting volumes overall, but must also cater for boarding demand during the AM peak period
- Redfern Station AM entry movements are relatively insignificant, with Redfern used primarily as an interchange and a destination station
- No demand currently to/from P10, but with the potential for usage in the future depending on future rail network upgrades.

In assessing the station design and layout alongside the patronage levels, the service frequency of each platform should also be considered. The service frequencies at Redfern Station are typically 18 to 20 trains per hour during the peak periods, with the exceptions of P1 (7tph), P5 (12tph) and P8 (10tph).

2 Summary of Peer Review of Previous Options

As part of the Peer Review of the Connell Wagner 2007 report, Arup reviewed the approach adopted to analyse Options C, D and E, and the performance of the proposed options. Following this process, Arup revised the modelling assumptions with respect to VT flow rates, and conducted a revised analysis of the options. This exercise focussed on the vertical transportation requirements to meet a 90 seconds platform clearance time, a criteria stipulated by RailCorp.

Figure 1 presents a comparison of the estimated platform clearance times for all Options at 2061 demand levels. The chart and analysis indicates the following:

- The majority of platforms are estimated to be subject to clearance times well in excess of 90 seconds for the Existing layout, and for Options D, E. Indeed, the clearances are greater than the headway of the train frequency on P2/P3, P4/P5 and P6/P7, which may incur network implications.
- Options D and E provide the greatest opportunity for clearing Platform 2/3, given the additional concourse bridge VT connection.
- Option C is the best performer at 2061 demand levels, both in terms of VT provision to achieve the target clearance times, and with respect to separation of the primary pedestrian flows.
- However, Option C offers minimal opportunity for increasing the existing stair widths, and cannot meet the 90 seconds clearance times on P1, P2/3 and P10 without the introduction of additional VT connections.

Arup's Peer Review of the Connell Wagner report is attached in the appendix. The peer review provides greater detail and discussion with respect to the performance of Options C, D and E, as well as an overview of the Connell Wagner analysis approach and demand data.

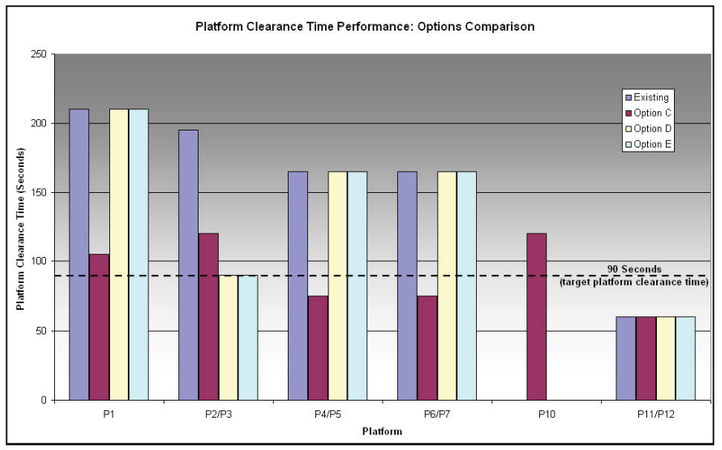


Figure 1 Platform Clearance Times for Options C, D and E, 2061 Demand

The following paragraphs summarise the overriding performance characteristics of Option C, detailing the shortcomings in VT provision and opportunities for mitigation.

2.1.1 Option C

The analysis of the VT provision performance proposed within Option C identified that the platform clearances times for P1, P2/P3 and P10 (for travel to P11/P12) were above the 90 seconds maximum criteria.

Table 2 below indicates the VT provision required to meet a 90 seconds clearance time for Option C.

Table 2 Option C Vertical Transportation Requirements

Platform	Option C Stair Width (metres)	Required Stair Width (metres)	Required Width Increase (metres)
1	5.0	5.8	0.8
2 / 3	3.6	4.4	0.8
4 / 5	4.0	4.6	0.6
6 / 7	6.5	6.5	-
10 (to 11/12)	4.0	6.5	2.5
11 / 12	3.0 & 2 Escs	3.0 & 2 Escs	-

A summary of the Option C platform clearance time analysis for 2031 and 2061 demand levels are presented below on Table 3 and Figure 2.

Table 3 Option C Platform Clearance Time Performance, 2061

Platform	Demand (pax in peak min)		Stair Width (metres)	Max Queue (per stair)	Platform Clearance Time (secs)
	Alighting	Boarding			
1	551	7	5.0	150	105
2 / 3	0 / 233	0 / 180	3.6	91	120
4 / 5	63 / 169	108 / 98	4.0	91	75
6 / 7	23 / 266	91 / 102	6.5	80	75
10 (to 11/12)	-	-	4.0	139	120
11 / 12	312 / 25	79 / 58	3.0 & 2 Escs	76	60

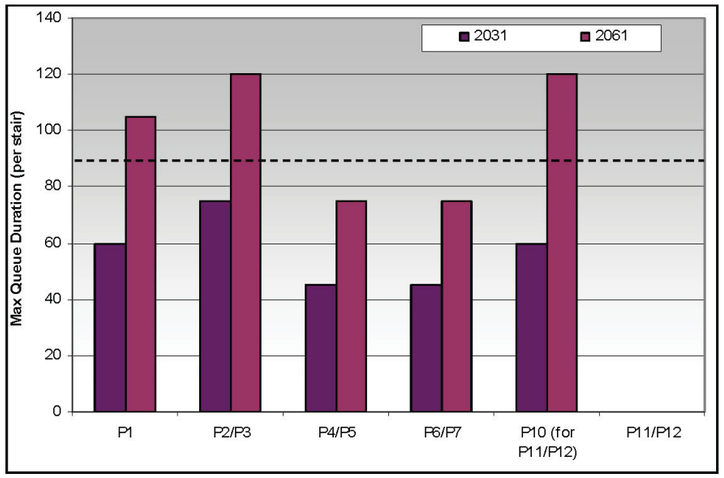


Figure 2 Option C Platform Clearance Time Performance, 2031 and 2061

However, understanding the constraints in platform space, especially for Platform 2/3, Arup recommended further investigation into design modifications that seek to create a more efficient balance of VT provision, as follows:

- Maintaining the existing stairs at the northern end to manage interchange flows and to minimise platform clearances and bi-directional conflicts on stairs
- A mixture of stairs and escalators where possible, to assist in efficiently managing the flows, whilst maintaining the appropriate spatial clearances form platform edge to any obstruction
- Additional VT on P10, or preferably via an alternative passage for P11/P12 passengers given the potential for P10 to be an operational platform in the future
- Any VT provision needs to be balanced with the station as a whole. P1 would benefit from more VT but with adverse affects to other platforms (primarily P2/P3). Therefore VT needs to be driven by weakest link.
- Except P1 clearances above 90 seconds given train frequency. Look to maximise clearances off P2/P3 by maximising stair width (requiring a concession if necessary).

3 Proposed Revised Concept Design

3.1 Outline of Issues / Design Principles

The preferred design taken forward from a pedestrian planning perspective was Option C. A number of the issues raised during the peer review stage have been investigated as part of the revised concept design process. In particular:

- The use of the existing northern stairs as an opportunity for interchange and fire egress
- The attractiveness of each entrance and the impact of interchange and entry/exit demands, especially for the major flows from P1 and to/from P11/P12
- Reducing bi-directional flow on P2/P3 given the narrow platform width and impacts to the associated stair width
- The option of introducing a centrally located concourse, which would connect to the platforms via additional VT and DDA lifts. In particular, the required capacity (width) of this concourse was evaluated as part of the value engineering process

This section outlines the concept design development, drivers and principles from a pedestrian planning perspective, considering the vertical transportation requirements, spatial parameters, and station amenity performance targets. The intention of the design principles is to design a station layout that performs to the expectation of its users'.

3.1.1 Vertical Transport Choice

In considering the preferred mixture of VT, it is imperative to firstly understand the pedestrian flows and movement patterns through the station.

Stairs offer the flexibility to cater for a mixture of flows, and are an efficient option for maximising the bi-directional capacity given a limited availability of VT space. If the station design restricts the number of VT points, stairs do allow all points to be accessed by all passengers. This can potentially decrease walk times to the VT, and can assist with platform distribution.

Escalators provide a higher flow rate per metre, and offer a better level of amenity in comparison to stairs, which is particularly preferable in overcoming significant level changes. If a sufficient number of escalators are provided, they can be configured to operationally manage the flows - separating bi-directional movements and reducing conflicts.

With respect to Redfern Station, there are a number of spatial constraints that limit the opportunity for VT. Bearing this in mind, a mixture of escalators and stairs is preferred to best cater for the nature of the demand to each platform. Without retention of the northern concourse, the platforms will only offer the centrally located VT connections; this platform width limitation can only provide single escalator banks (2 escalators in total per platform) either side of the concourse bridge (1 Up, 1 Down). This configuration will encourage increased movements through the narrowest point on platform level (adjacent to the VT, under the concourse bridge), as passengers walk to their nearest VT point.

The benefit of stairs is notable on Platform 2/3 where the significant bi-directional flow requires VT capacity in both directions, and where the stairs are best equipped to achieve a platform clearance time approaching 90 seconds.

In contrast, the demand relating to Platform 1 is largely uni-directional. During the AM, the P1 flow is dominated by alighting interchange and station exit passengers. Hence, escalators would ideally serve this demand, in addition to a stair that can cater for the minimal counter flow. However, the choice of VT for each platform should be considered as a system; an imbalance in VT capacity for interchange movements can result in queueing at the most constrained VT within the system. This queueing could occur at the VT boarding

area within the concourse, with potential repercussions to concourse circulation and congestion.

3.1.2 Concept Design Development

An early stage of the design process estimated the performance of a station layout with the existing northern concourse and stairs maintained for interchange movements. The analysis of this design assumed:

- Stair widths as initially proposed in Option C (as detailed in Table 3)
- The existing (northern) stairs are maintained and 50% of all interchange movements use the existing stairs. The remaining 50% of interchanges (and all entry/exit movements) use the new concourse
- A link to P11/P12 from the existing northern stairs is maintained

The pedestrian performance of this operation is summarised in Figure 3. In summary:

- All stairs clear within 90 seconds at 2061 demand levels
- P2/P3 has the greatest benefit – given the reduction in bi-directional flow on the narrow stairs feeding the main concourse.

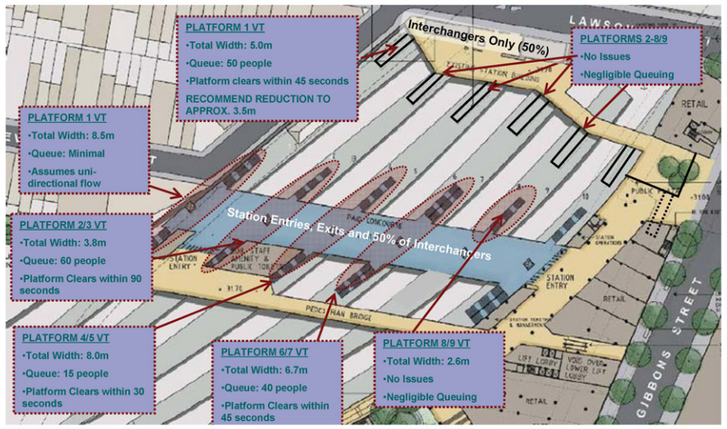


Figure 3 Performance of vertical circulation with existing northern stairs maintained

Although maintaining the northern stairs is recommended from a pedestrian planning perspective, the decision has significant impacts to DDA regulation. DDA requirements state that equality for disabled users would require lifts to be installed at the old concourse to provide easy access. Therefore the design team also considered an option which included the removal of the existing concourse and stairs (although not available for normal operations, the stairs are available for emergency egress scenarios). This option assumes the following:

- Stair widths as initially proposed in Option C (as detailed in Table 3)
- All interchange and all entry/exit movements use the new concourse
- A link to P11/P12 from the existing northern stairs is maintained

The pedestrian performance of this operation is summarised in Figure 4. In summary:

- All stairs clear within 90 seconds at 2061 demand levels, except Platform 2/3 which clears in 105 seconds.
- P2/P3 is assumed to be at a width of 3.8m, requiring an additional 0.6m to meet the target of 90 seconds platform clearance time. The queue population at this time is estimated to reach a maximum of 80 people.

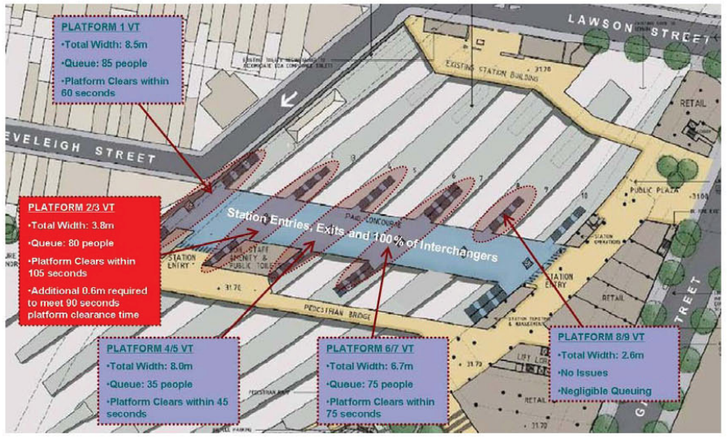


Figure 4 Performance of vertical circulation with removal of existing northern stairs

3.1.3 Gateline Requirements

Arup have reviewed the AM 2061 station entry and exit demand to understand the required gateline provision at both the east and west station entrances. The proportion of passengers to each entrance is based on the east/west splits outlined within the peer review report, which were developed using a combination of the 2008 gateline data and the RWA employment forecasts. At 2061, the west entrance is assumed to capture 41% of demand, and the east entrance is assumed to capture 59%.

The gateline estimates are based on the London Underground SPSG guidelines (5th edition), and has identified a requirement for a total of 22 gates at Redfern Station given 2061 demand levels.

3.1.4 Spatial Parameters

The following spatial parameters are recommended for Redfern Station:

- A minimum concourse width of 12m – 14m is recommended. This estimate is based on a high level static assessment, and considers the width requirements of both circulation corridors and space associated with the VT run-offs and waiting areas.
- A minimum of 3 metres run-off is recommended at the top of stairs, and 4-6 metres from the gateline. This run-off is suggested to avoid conflicts between flows and queueing areas, and to assist with orientation and wayfinding.

4 Crowd Modelling Assessment

The Concept Design has been assessed from a passenger experience perspective. The analysis of this design assumes:

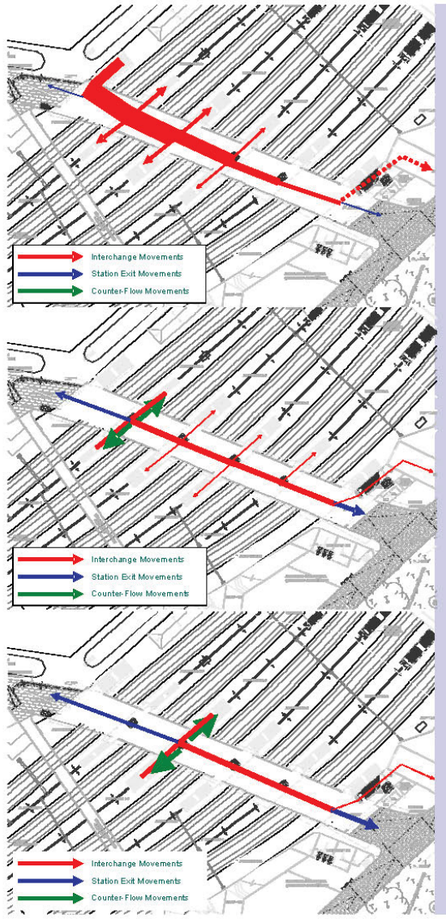
- The existing northern concourse and stairs are not maintained for normal operations (only for emergency egress).
- Therefore, all interchange movements and all entry/exit movements use the new centrally located concourse.
- A new link to P11/P12 from the centrally located concourse is proposed, via 2 escalators and a walkway ramp to the mezzanine level, and then via a 4m stair or 2 escalators to P11/12 platform level.
- A new 4m wide unpaid link is proposed, and will connect from western station plaza to Marian Street at the southeast for use by pedestrians and cyclists.

Overall the Concept Design provides improved passenger amenity with respect to east-west links and vertical provision, significantly improving platform clearance times and quality of journey experience. Moving further into the design process, the pedestrian analysis of the design has identified the following recommendations to consider/recognise.

- The volume of alighting passengers from Platform 1 (approx. 550 in 2061) will clear in approximately 150 seconds. Although additional VT capacity would achieve an improved P1 clearance time, the P1 VT capacity will need to be balanced with the downward capacity of the VT to the destination platform. Given the relatively low service frequency of trains on P1, consideration should also be given to tolerating a clearance time of >90 seconds.
- Further VT width is required to serve Platform 2/3 in order to meet the target 90 seconds platform clearance time. However, given the spatial constraints (the P2/3 platform width), it is noted that there is limited opportunity to increase the VT capacity to P2/3 and platform clearances meet targets up to 2053.
- The existing northern concourse provides an opportunity to act as an interchange route, which would provide additional overall VT capacity and separate the primary flows, alleviating demand to the new central concourse VT.
- The layout of the interface between the gatelines and the paid concourse VT need to ensure that run-off areas are not overlapping and conflicting.

4.1 Pedestrian Flows

The AM flows at 2061 demand levels are presented on the following plans. The flows relate to the peak train alighting and boarding volumes for each service, and demonstrate the relative magnitude of station entry, station exit, and interchange flows.



Platform 1

Significant alighting loads, dominated by interchange flows (to P2/3, P4/5, P6/7 and P11/12).

Minimal demand to Platform 1 during AM peak.

Peak Boarding Load: 5

Peak Alighting Load: 550

Platform 2/3

P2/3 is a critical platform with respect to both boarding and alighting during the AM peak.

A substantial aspect of this demand is interchange, particularly from P1 and P11, and interchanging to P7 and P12.

Peak Boarding Load: 140

Peak Alighting Load: 230

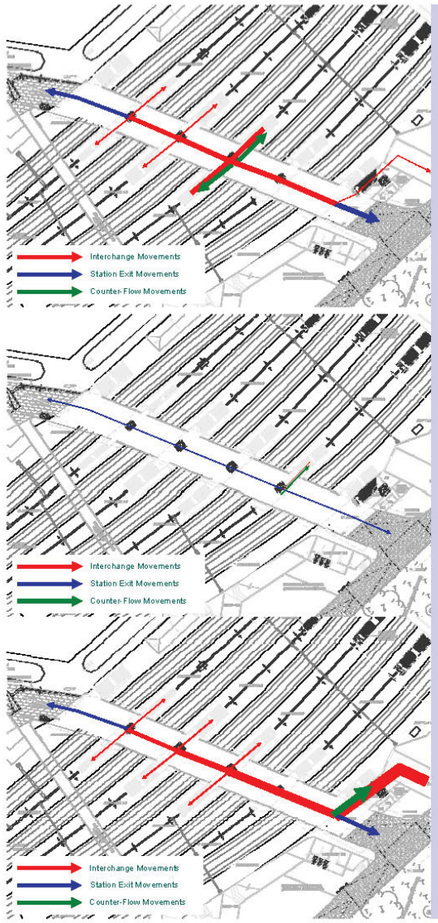
Platform 4/5

P4/5 is similar to P2/3 in that is it subject to significant bi-directional flow.

The major flow is interchange demand from P1 and P11.

Peak Boarding Load: 95

Peak Alighting Load: 170



Platform 6/7

P6/7 is also exposed to bi-directional flow, particularly following the arrival of interchange passengers on either P11 or P1.

Station entry and exit movements provide a steady flow of passengers to and from P6/7.

Peak Boarding Load: 100

Peak Alighting Load: 270

Platform 8/9

P8/9 does not attract significant demand, with relatively low volumes of both interchange and station entry/exit movements.

Peak Boarding Load: 10

Peak Alighting Load: 25

Platform 11/12

P11 is a significant interchange platform, with 1 peak load of approximately 150 passengers transferring from P11 to other platforms during the AM peak.

Peak Boarding Load: 70

Peak Alighting Load: 310

4.2 Vertical Transportation

The pedestrian planning performance of the VT provision is summarised in Table 4 and Table 5, and is summarised as follows:

- The stair flow rates adopted within the VT analysis are extracted from the Connell Wagner VT assessment report; 35 ppm for bi-directional movement, 50ppm for uni-directional movement.
- The single 4m wide stairs provided on Platform 1 offers insufficient capacity to cater for the peak 2061 alighting load of 550 passengers, and will take approximately 150 seconds to clear. An additional 1.8 metres is required to achieve the target of 90 seconds. A second stair connecting to the south

side of the concourse would increase the overall capacity, but clearly needs to be considered alongside other station design drivers.

Furthermore, although the additional VT capacity would achieve an improved P1 clearance time, the P1 VT capacity will need to be balanced with the downward capacity of the interchange platforms (P2/3, P4/5, P6/7, P11/12).

The service frequency of P1 is expected to be 7tph in 2061, which implies an average headway of 8 to 9 minutes. A platform clearance time of >90 seconds may therefore be tolerated on P1, although the overall journey times for P1 interchange passengers would be significant (estimated to be approaching 4 minutes inclusive of the 150 seconds queue time).

- P2/P3 is assumed to be at a width of 3.8m, requiring an additional 0.6m to meet the target of 90 seconds platform clearance time. The queue population at this time is estimated to reach a maximum of 80 people. However, understanding the spatial limitations inherent with the narrowness of P2/3, there are limited opportunities to increase the VT capacity without significant re-design, or maintenance of the existing northern concourse.
- All other platforms cater for the anticipated 2061 demand levels within the 90 seconds clearance time criteria.
- Although the VT serving the alighting loads on P11/12 can meet 90 seconds clearance time target, the VT provision from the transfer concourse to the concourse bridge (1 escalator UP) will be a bottleneck. A queue of up to 100 persons is estimated to form at the base of the escalator, with up to a minute of queueing likely.

Table 4 Concept Design Platform Clearance Time Performance, 2061

Platform	Demand (pax in peak min)		Stair Width (metres)	Max Queue (per stair)	Platform Clearance Time (secs)
	Alighting	Boarding			
1	551	7	4.0	340	150
2 / 3	0 / 233	0 / 180	3.8	80	105
4 / 5	63 / 169	108 / 98	8.2	31	45
6 / 7	23 / 266	91 / 102	6.6	74	75
10 (to 11/12)	-	-	4.0	-	-
11 / 12	312 / 25	79 / 58	4.0 & 2 Escs	44	45

Table 5 Concept Design Vertical Transportation Requirements

Platform	Concept Design Stair Width (m)	Required Stair Width (metres)	Required Width Increase (metres)
1	4.0	5.8	1.8
2 / 3	3.8	4.4	0.6
4 / 5	8.2	4.6	-
6 / 7	6.6	6.5	-
10 (to 11/12)	4.0	-	-
11 / 12	4.0 & 2 Escs	3.0 & 2 Escs	-

4.3 Gateline

A comparison of the required gateline provision against the Concept Design provision is provided below on Table 6.

Table 6 Gateline Requirements, AM, 2061

Station Entrance	Recommended # of gates (incl. DDA)	Concept Design Provision
East	13	12
West	9	9

Although the Concept Design does not currently show the recommended gateline provision at the east entrance, sufficient width is available for an additional gate at the east entrance.

The gateline provision recommended above is based on 2061 demand levels, and can be introduced in stages as to reflect the annual gateline requirements. For example, in 2031, it is estimated that a total of 17 will be required across both the east and west gatelines.

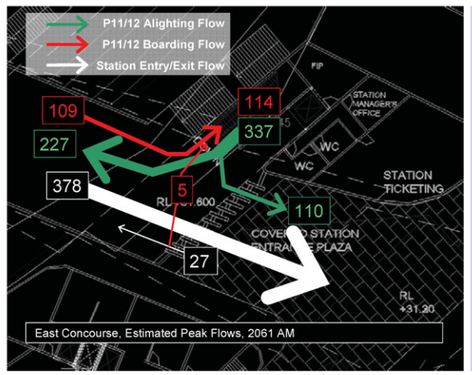
4.4 Spatial Review

The Pedestrian Planning team have considered the spatial requirements of Redfern Station, based on a combination of best practice and demand analysis. A summary of the findings of this review alongside the Concept Design performance is below:

- The Concept Design provides between 12m and 13m of concourse width, and is therefore in accordance with the pedestrian movement requirements (12m minimum). However, given that the concourse is not positioned perpendicular to the VT, the layout is not fully efficient with the available width.

Given the complex mix of bi-directional flows and waiting/queueing behaviours predicted within this space, a dynamic simulation of the concourse would be required to fully understand and finalise the concourse width requirements and performance.

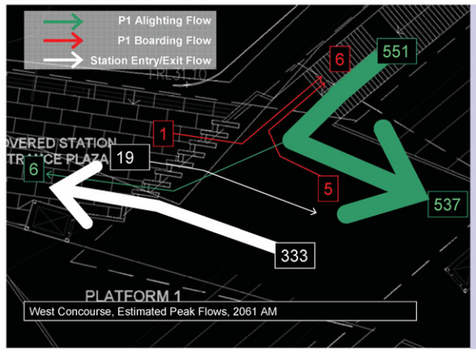
A minor modification of VT and gateline placement has been undertaken to achieve the minimum run-off requirements at both gatelines. Further detail of the pedestrian flows adjacent to each gateline is presented on the diagrams below:



East Entrance

The diagram illustrates the flows associated with a Platform 11/12 peak train arrival (boarding/alighting), alongside the peak minute station entry/exit movements.

The mix of flows at the gateline/escalator interface is accommodated by setback of the gateline into the entrance plaza.



West Entrance

The diagram illustrates the flows associated with a Platform 1 peak train arrival, which is dominated by alighting loads.

The mix of flows at the gateline/escalator interface is not a key issue as the flows is likely to be uni-directional.

Separation of the flows is recommended through configuration of the gates (station exit gates at south end)

2