RISK ASSESSMENT

Derailment Scenarios
on
Down Local Line
adjacent

Residential Development
2 Pilgrim Ave
Strathfield

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Contents

1. SUMMARY

A derailment risk assessment has been undertaken for structures in the commercial and residential development at 2 Pilgrim Avenue, Strathfield located 15m from the Down Local West rail track centreline. The study has been conducted in accordance with the External Developments Standard T-HR-CI-12080-ST and appropriate Technical Notes. The purpose is to determine appropriate load requirements specified in AS 5100 as mitigation to manage the risk of collision from a derailed train on the adjacent line. The risk assessment takes into account:

- Site condition (track on embankment, 15m clear of structures)
- Derailment history (nil incidents on this section that impact the development)
- Type of structure and potential for collapse and consequential damage
- Track geometry (minor falls in gradient towards Homebush, fit for purpose, curves away on approaches to and past site)
- Track features - departure signal on the Down Local after Strathfield Station Platform 8 and before the Raw Square Overbridge and another signal opposite the western edge of the development; no associated catchpoints or discontinuities given the only crossover and associated 603 points that are down the track at Homebush Station Platform 1 and used by terminating trains to shunt to Homebush and return on the Up Local
- Track speed Down Local Line (recommended 50kph, max approach 80kph)
- Type of rollingstock (passenger trains)
- Future use and growth and developments

The proposed building development will not impact the likelihood of a derailment or collision but may alter the profile of persons potentially at risk by introducing:

- Additional persons exposed in (occupants) and around the buildings
- Additional exposure to train passengers and train crew in the event of a derailment travelling as far as the building and causing a structural collapse

In the event of an incident the risk to an individual is a function of the probability of fatality per incident based upon the numbers and groups exposed, the train movements and incident frequency. The **quantitative** risk model analysis for clearance 8m estimated:

- Derailment incident potentially impacting building once every 997 years
- Societal risk considering the number and categories of persons exposed in train and building as a consequence of derailment during a fatal incident impacting 4 to 44 persons normalises to a Potential Loss of Life (PLL), once every 1,608 years

The desk-top **qualitative** assessment using the risk matrix found:

- Likelihood derailment on the Local Down line proceeding beyond site boundary and striking a structural element = L6 (Almost Unprecedented). Consequence following derailment and collision as a result of the new buildings located to centreline adjacent Down Local located:
  1 Fatality (PLL) to 10-20 Major Injuries = C2 (Severe)
- Risk Level:
  L6 x C2 = C2 (Medium)

T-HR-CI-12080-ST applies the result of the risk analysis to determine the category of loading requirement from AS 5100 Table 1, clause 5.13, ‘Collision Loading Requirement’ for support structures located within 20m from the centre line of the adjacent track. This report finds that in accordance with the qualitative assessment (Appendix A) for the risk ranking of ‘C’ using the TfNSW TERM risk matrix and the link to specification in AS5100:

Qualitative Risk (TERM)	Offset over 10m
Likelihood of Derailment	L6 (<1x100yrs)
Potential Consequence	C2 (Single Fatality)
Level Risk – Initial	L6 x C2 = 'C' (Medium)
– Mitigation Measure(s)	Nil Mandatory
Level Risk – Residual with Mitigation	L6 x C2 = 'C' (Medium)

In accordance with the Office of the Rail Safety National Regulator ONRSR Guidelines 2016, the So Far As Is Reasonably Practicable (SFAIRP) application process has progressed through a hierarchy of controls including:

- Elimination, that is not possible since the line will continue to be utilised and the track, environment and rollingstock faults cannot be eliminated; thence
- Practical and cost justified options that prevent else mitigate the risk, given application of appropriate rules, regulations and standards

The SFARIP justification case and application of the appropriate standard AS 5100.1 concludes that given the offset is over 10m and structural redundancy complies with AS5100.1, the risk assessment concludes that additional collision mitigation is not mandatory subject to approval by relevant authorities.

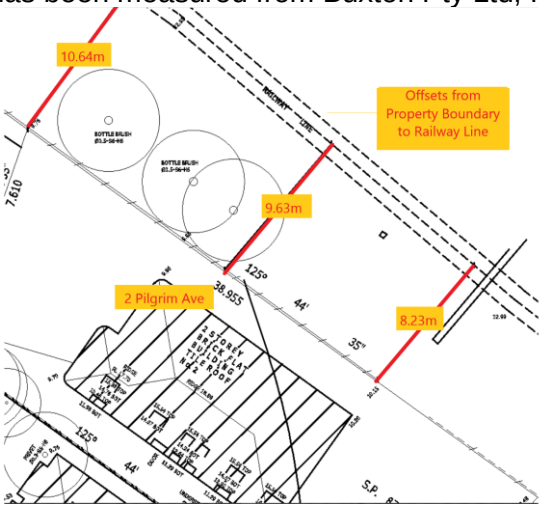
2. BACKGROUND

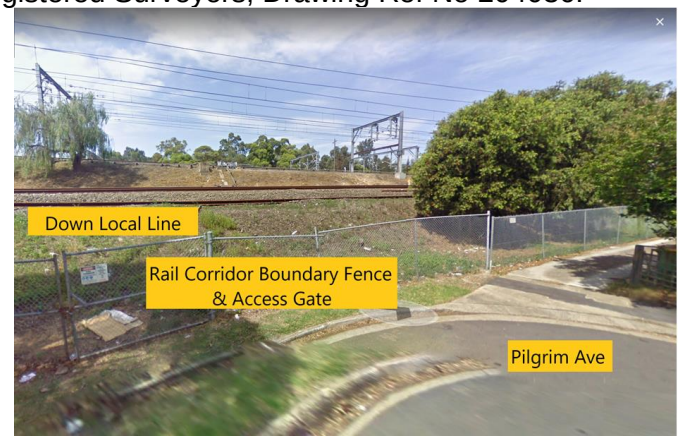
The derailment assessment is based upon rollingstock, track, formation and topographic conditions and clearances between the Down Local West Line and the adjacent structural elements of the proposed development between Strathfield and Homebush Stations and addresses potential derailment scenarios illustrated in section 4. The clearance from the centre line of the adjacent track to the boundary varies from 10.64 – 8.23m and the building is set back a further 7.61m from the boundary – that is an offset of the centre line of the nearest running rail of over 15m. These are the critical rail-structure interface configuration dimensions used in the quantitative analysis model and qualitative assessment with regards the risk of a derailment on the track adjacent the development site or a train derailing on the points and crossings identified in section 4.

2.1 LOCATION

The development is an amalgamation of sites and has a combined area of approximately 2868m2 (by title) adjacent the rail corridor on the northern side between Strathfield and Homebush Stations:

The offset clearance from the centre line of the Down Local Line to the property boundary has been measured from Buxton Pty Ltd, Registered Surveyors, Drawing Ref No 204036:

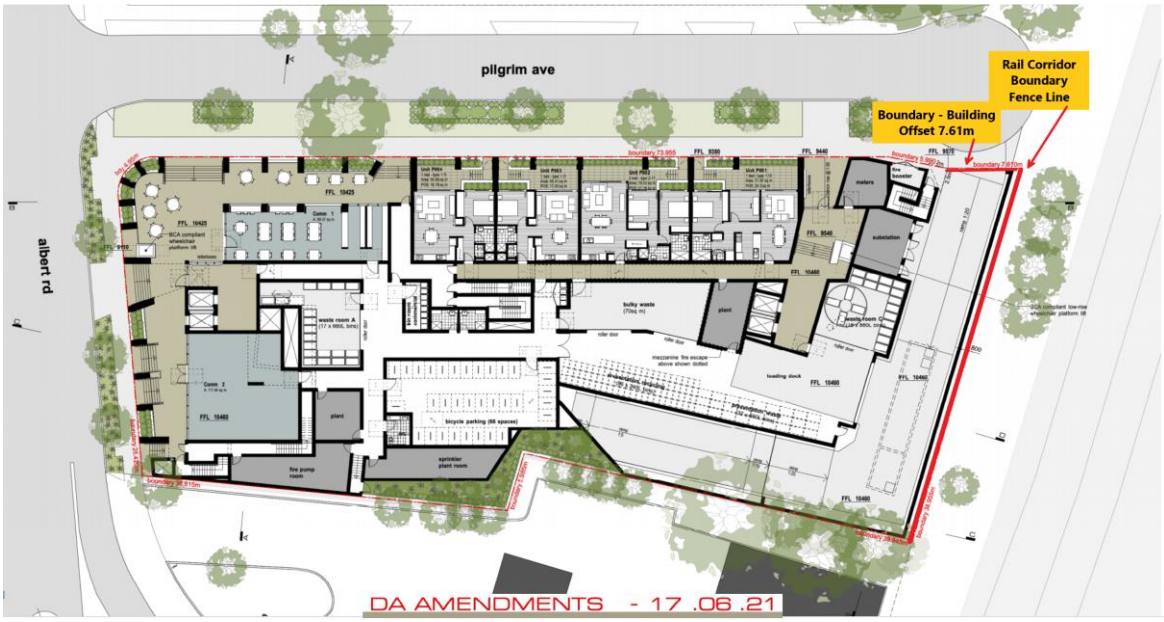




Take offs from
Buxton Pty Ltd, Registered Surveyors
Ref No 204036

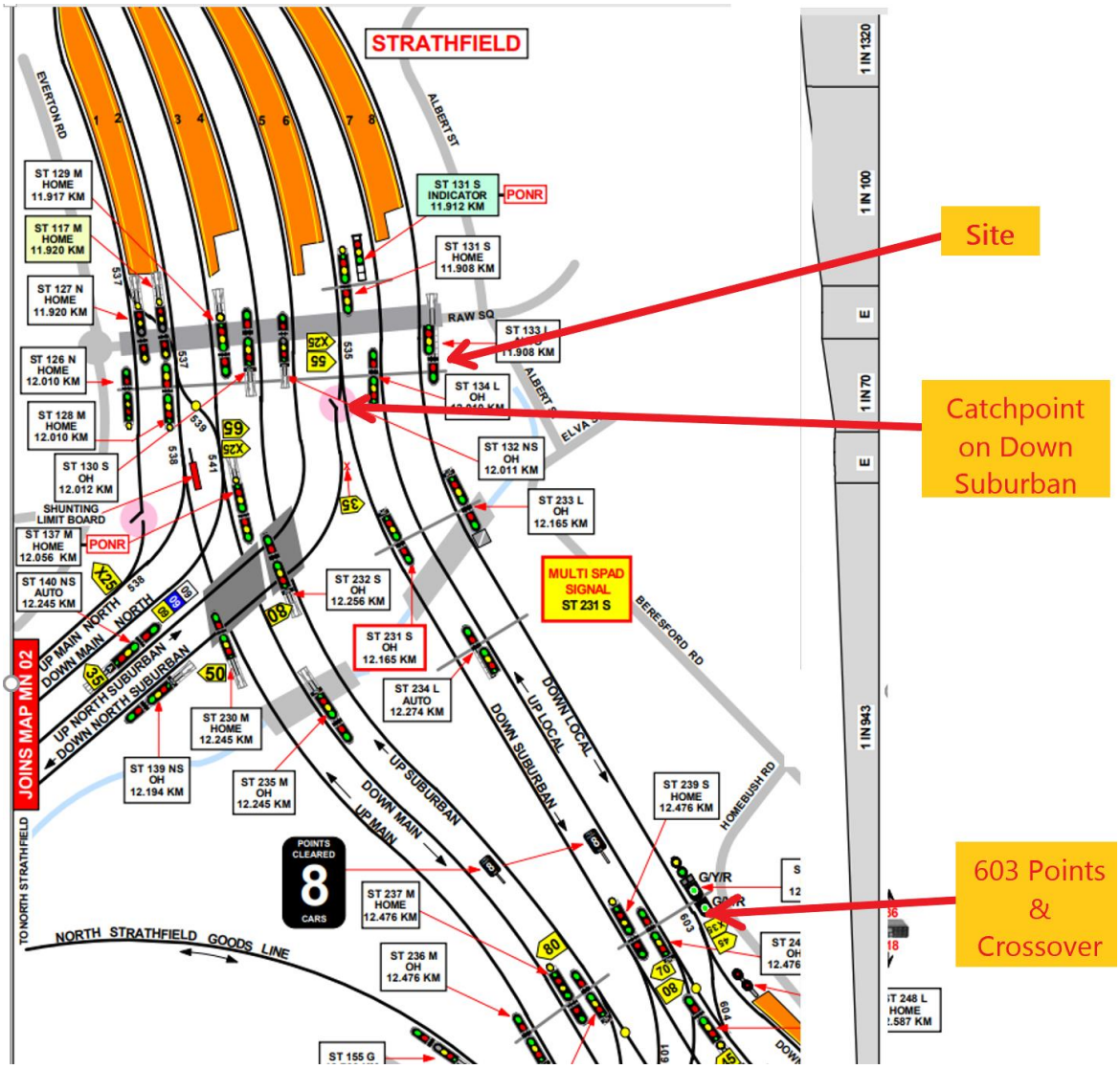
2.2 SITE LAYOUT & SCHEMATIC

The development is 17 storey with 2 levels of commercial, 1 level of childcare and 14 levels of residential. There is 1 level of basement to the western (railway) side and 2 levels of basement to the eastern side. The relevant building configurations are considered in the following analysis and assessments are illustrated below:



2.3 TRAIN DRIVERS DIAGRAM

The Train Driver's Diagram provides a diagrammatic overview of the sectional running and infrastructure:



3. RISK ASSESSMENT METHODOLOGY

3.1 HAZARD IDENTIFICATION

A hazard and risk worksheet has been completed as part of desk-top exercise in accordance with Safety Management System SMS-06-PR-0030, 'Hazard Identification and Safety Risk Assessment Guide SMS-06-GD-0031and AS/NZ 4360-2004. It was conducted in consultation with appropriate stakeholders, Subject Matter Experts and clauses Engineering Standard T-HR-CL-12080-ST External Developments.

3.2 STAKEHOLDERS & SUBJECT MATTER EXPERTS

Information and advice have been obtained from previous reports, telephone consultations and discussions with the following stakeholders and Subject Matter Experts (SME):

Manager Reliability Improvement, Sydney Trains
No derailment incidents are recorded on this specific section in the Sydney Trains Incident Information Management System (IIMS). However, the following incidents were recorded in this area of the corridor and provide evidence of derailment dynamics:

- 13/5/91 Strathfield – w561 derailed wheels 5, 6, 7, 8 at V crossing 12.100 km Down Local West (other side of Strathfield Station towards Homebush Station); derailment due to rolling stock irregularities (loose underframe)
- 2/8/94 Strathfield – Loose sort on run 35-L struck stanchion
- 10/4/98 Strathfield – station staff reported explosive sound emitted from car No 3952 in consist of run 43B; wire entangled in pantograph
- 3/8/04 Strathfield – roof hatch cover on the lead car 1045 of Run 759H detached and damaged the pantograph on the fourth position car 1046. This resulted in the contact wire in the area being damaged and a sustained fault being recorded on the OHW system.
- 7/1/14 and 27/8/14 Strathfield – truck struck overhead bridge

3.3 RISK CRITERIA

In accordance with T-HR-CI-12080-ST that has been developed from ESC 380 in which the legacy Clause 5.13, provided loading requirement decision criteria that linked to AS 5100 2004 as follows:

Safety Risk Matrix Ranking	AS 5100 2004 Collision Loading Requirements
A	AS 5100.2 clause 10.4.3 (using loading for between 10m and 20m from centre line of track), clause 10.4.4, clause 10.4.5 and clause 10.4.6
B	AS 5100.2 clause 10.4.4 and clause 10.4.6
C	Nil
D	Nil

This has been updated in following table correlates the link to AS 5100 2017:

Safety Risk Matrix Ranking	AS 5100 Collision Loading Requirements	
	2004	2017
A	All requirements of AS 5100.2 clause 10.4.3, clause 10.4.4, clause 10.4.5 and clause 10.4.6	All requirements of AS 5100.2 clause 11.4.2.3 Support within 10m of centre line of adjacent track 4000KN parallel rails & 1500KN normal to rails, 11.4.2.4 10-20m risk assess for approval by relevant authorities and if redundancy does not meet AS 5001.1 requirements design collision loading 1500KN at any angle from track & 2m above ground level
B	AS 5100.2 clause 10.4.3	AS 5100.2 clause 11.4.2.3 Support within 10m of centre line of adjacent track 4000KN

	(using loading for between 10m and 20m from centre line of track), clause 10.4.4, clause 10.4.5 and clause 10.4.6.	parallel rails & 1500 KN normal to rails. AS 5100.2 clause 11.4.2.4 10-20m risk assess for approval by relevant authorities and if redundancy does not meet AS 5001.1 requirements design collision loading 1500KN at any angle from track & 2m above ground level
C	AS 5100.2 clause 10.4.4, clause 10.4.5 and clause 10.4.6.	AS 5100.2 clause 11.4.2.3 Support within 10m of centre line of adjacent track 4000KN parallel rails & 1500 KN normal to rails. AS 5100.2 clause 11.4.2.4 & AS5100.1 15.3.2 Protection Supports 10-20m from centre line adjacent track risk assess for approval by relevant authorities
D	AS 5100.2 clause 10.4.4 and clause 10.4.6.	AS 5100.2 clause 11.4.2.3 Support within 10m of centre line of adjacent track 4000KN parallel rails & 1500 KN normal to rails. AS 5100.2 clause 11.4.2.4 & AS5100.1 15.3.2 Protection Supports 10-20m from centre line adjacent track risk assess for approval by relevant authorities

3.4 RISK ACCEPTANCE CRITERIA

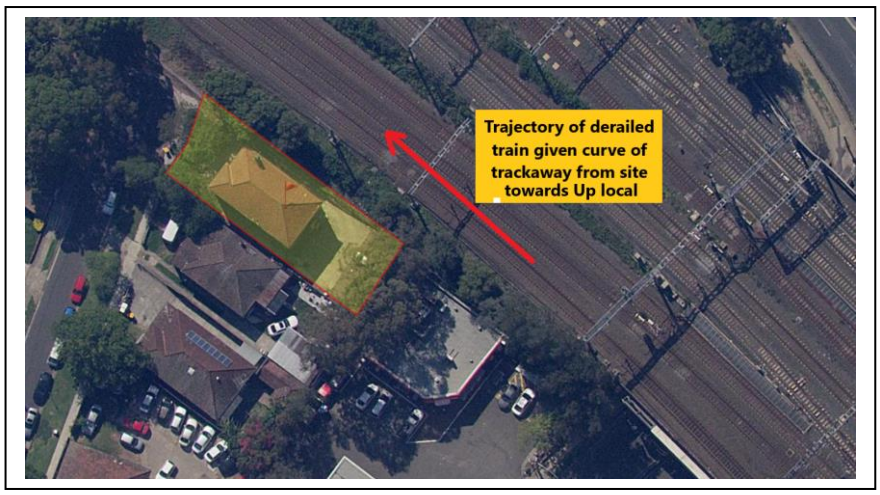
In accordance T-HR-CI-12080-ST External Develops the Standard 30-ST-164 v2.0, TERM Matrix has been used in the assessment process of the impact of estimated frequency of hazardous events and their potential safety consequences:

TERM Health & Safety (Injury) Risk Matrix			Consequence						
		Workplace Historical (Likelihood)	Illness, first aid or injury not requiring treatment.	Illness or Minor Injuries requiring medical treatment	Single recoverable Loss Time Injury or illness, alternate / restricted duties injury, or short term occupational illness	1-10 Multiple Injuries requiring hospitalization and numerous days lost, or medium term occupational illness	Single Fatality and/or 10-20 major injuries / permanent disabilities, chronic diseases	Multiple Fatalities and/or >20 major injuries / permanent disabilities, chronic diseases
			C6	C5	C4	C3	C2	C1
Likelihood / Frequency			Insignificant	Minor	Moderate	Major	Severe	Catastrophic
10 times or more per year	Expected to occur frequently during time of activity or project	L1 Almost Certain	C – Medium	B - High	B - High	A – Very High	A – Very High	A – Very High
1 to 10 times a year	Expected to occur occasionally during time of activity or project	L2 Very Likely	C – Medium	C – Medium	B - High	B - High	A – Very High	A – Very High
Once each year	More likely to occur than not occur during time of activity or project	L3 Likely	D - Low	C – Medium	C – Medium	B - High	B - High	A – Very High
Once every 1 to 10 years	More likely not to occur than occur during time of activity or project	L4 Unlikely	D - Low	D - Low	C – Medium	C – Medium	B - High	B - High
Once every 10 to 100 years	Not expected to occur during time of activity or project	L5 Very Unlikely	D - Low	D - Low	D - Low	C – Medium	C – Medium	B - High
Less than once every 100 years	Not expected to ever occur during time of activity or project	L6 Almost Unprecedented	D - Low	D - Low	D - Low	D - Low	C – Medium	C – Medium

4. DERAILMENT SCENARIOS

The following illustrate the kinematics and trajectories of derailment scenarios that have been considered for quantitative and qualitative risk analyses in the following sections:

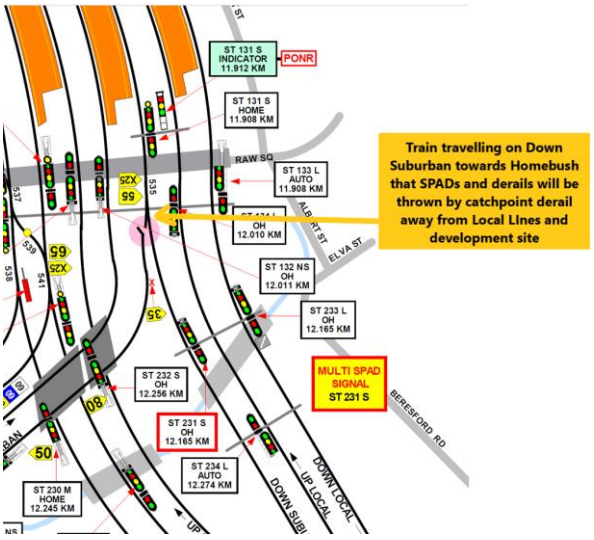
4.1 NORMAL DOWN LOCAL WORKING



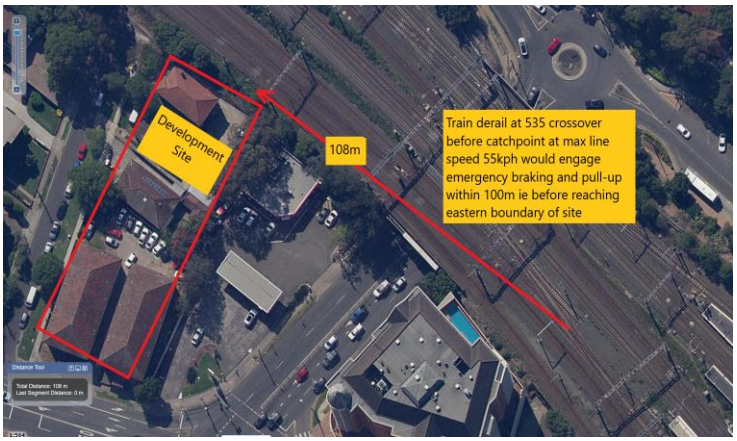
4.2 SCENARIO TESTING – CATCHPOINT & CROSSOVER

Specific risk scenarios have been reviewed for derailments at points on the following cross-overs – and illustrated on the driver diagram section 1.3.

- 535 boarded line speed 55kph and crossover 25kph scenarios as follows:



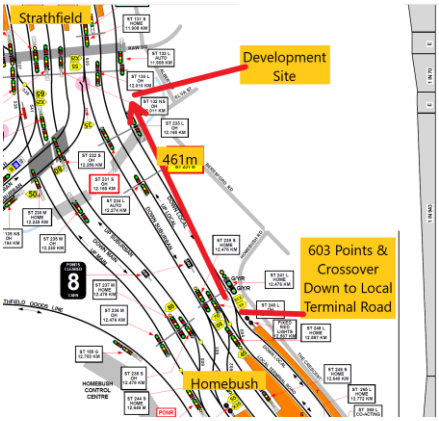
Most likely derailment scenario (ref Drivers Diagram above):
Associated signal ST131 has catchpoint on Down suburban with derailment throw away from Up & Down Locals ie derailed train travelling away from site and no likelihood of impacting buildings



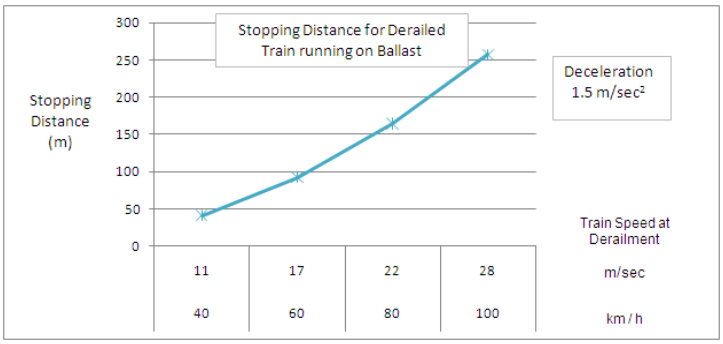
Most unlikely derailment scenario (ref 6 Map diagram above):
Train derails at max line speed 55kph ie 30kph above boarded crossover speed, before reaching catchpoint and travels toward Homebush:

- Derailed train will most likely be constrained for lateral displacement toward Down Local and the site by being constrained by the Local Lines, noting that the Down Suburban is on a minor embankment above these line
- In the unprecedented event that it was not constrained laterally, the derailed train would be pulled up by emergency braking and/or resistance from travelling oon ballast, within max 100m, that is before reaching the eastern boundary of the development site
  (ref SPC230 Appendix L deceleration of 3m/sec2 on 300mm deep ballast used in design of ballast drags)

- 603 from Down Local to Terminal Road at Homebush Station.
  Line speed 45kph, crossover boarded at 35kph, in the event of a reverse working ie from Terminal Road to Down Local, derailed train at this location would pull up within 50m, well before reaching development site some 461m beyond.



Derailed train at 603 points would pull up well before development site and likelihood of reaching site is unprecedented



Stopping Distance for Derailed Train running on Ballast

5. DERAILMENT RISK

5.1 RISK ASSESSMENT

The process of review and discussions with stakeholders and Subject Matter Experts has been to compare:

- Site Specific Hazards to average on Electric Network
- Operating Specific Hazards to average on Electric Network

5.2 SITE SPECIFIC FEATURES

Current passenger timetable for Down traffic is as follows:

Line	Down Local
Week day passenger traffic	140
Weekend day passenger traffic	130
Weekly passenger traffic	960
Annual passenger traffic *	46,080

* *based upon 48 weeks annual operations ie excluding 4 weeks track possessions and closedowns*

- Site condition - parallel rail corridor that is on a slight embankment above the site
- Derailment history - nil derailment or collision incidents that would impact development
- Type of structure and potential for collapse damage to trains - 12 storey of residential and ground floor commercial comprising 172 units with 4 levels of basement parking
- Track condition - track fit for purpose, minor curve away from site, on level to falling 1:70 towards Homebush Station
- Track features - departure signal on the Down Local after Strathfield Station Platform 8 and before the Raw Square Overbridge and another signal opposite the western edge of the development; no associated catchpoints or discontinuities given the only crossover and associated 603 points that are down the track at Homebush Station Platform 1 and used by terminating trains to shunt to Homebush and return on the Up Local
- Track speed Down Local - recommended 50kph, max approach 80kph
- Type of rollingstock (passenger electric trains)
- Future use and growth and developments

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The following summarises the site-specific features:

Line	Passenger
Maximum approach speed study area	50
Recommended approach Speed (100m)	80
Approaching Train Status	Coasting approaching Strathfield Station
Movements per annum	46,080
Infrastructure Features	
Rail Curvature	Curve away from site site
Gradient	1:70 towards Homebush
535 xover boarded line speed 55kph and crossover 25kph	1
603 xover boarded 25kph from Down Local to Terminal Road at Homebush Station.	1
Signals	2

- Sydney Trains Drivers Diagram (DKRD) Main-South-Line-Central-to-Macarthur-via-Regents-Park
- Location of Speed Signs Train Operating Conditions (TOC)

5.3 REVIEW OF HAZARDS

The likelihood of a derailment occurring is a function of the presence of hazards identified as having the potential to cause an incident at this location, and modifications to the generic derailment incident frequency have been reviewed in a desk-top exercise following discussions with Subject Mater Experts (SMEs) and a review of the historical incident information sources that indicated no derailment or collision incidents on this section of the rail corridor that would impact the development.

5.4 ROOT CAUSE ANALYSIS

The track is maintained fit for purpose condition, concrete sleepers with 60kg rail. The track condition, configuration and incident review were used to modify the Generic Network Incident Count sample to reflect Site Specific hazards as follows:

	PASSENGER TRAINS		
Down Local	Historical Frequency per Train Movement Km	Site Factor *	Total
Shunting Irregularity	5.63E-09	1	5.63E-09
Spread road	1.88E-09	1	1.88E-09
Vandalism	9.38E-09	2	1.88E-08
Heat buckle	1.88E-09	1	1.88E-09
Formation subsidence			
			2.81E-08

* *Scores from Risk Model range from Highly probable 10 to Probable 1, to Improbable 0.1 to Nil 0*

Down Local	**PASSENGER TRAINS** Historical Frequency per Train Movement Km	Site Factor *	Total
Points incorrectly set	1.13E-08	1	1.13E-08
Excessive Speed	3.75E-09	1	3.75E-09
Points or crossing irreg	9.38E-09	1	9.38E-09
Points detection defects	1.88E-09	1	1.88E-09
Incorrect Route	3.75E-09	1	3.75E-09
			3.00E-08

HAZARD AREA ROLLINGSTOCK and OPERATIONAL HAZARDS

Rolling stock and operational hazards have been assumed to be consistent across the network and hence have not been modified for line or site specific factors and:

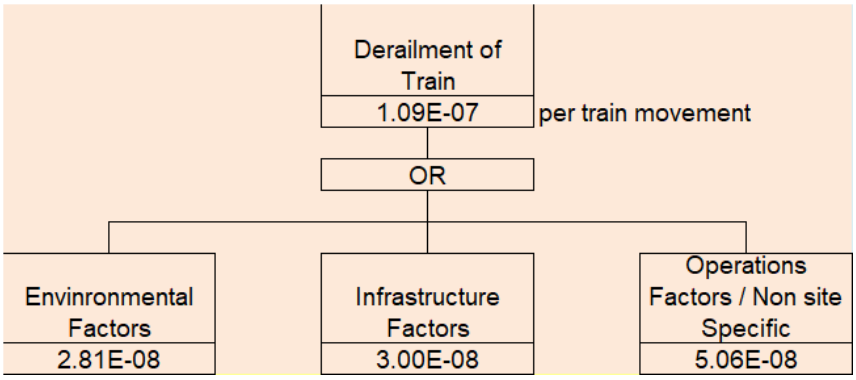
- Passenger trains = 5.06E-08 historical frequency per train movement km
- Freight trains = 1.09E-06 historical frequency per train movement km

5.5 FAULT TREE ANALYSIS

The likelihood of a derailment occurring on the Down Local West is a function of the presence of hazards identified as having the potential to cause an incident at this location, and modifications to the generic derailment incident frequency that were reviewed in section 4.

The site specific frequency of derailment within the nominated track profile adjacent the support structures for the proposed development adjacent the rail line at 2 Pilgrim Ave, Strathfield is then summarised as illustrated on fault trees and the results that are incorporated in the Event Tree Analysis of the following section

PASSENGER TRAINS – *Down Local*

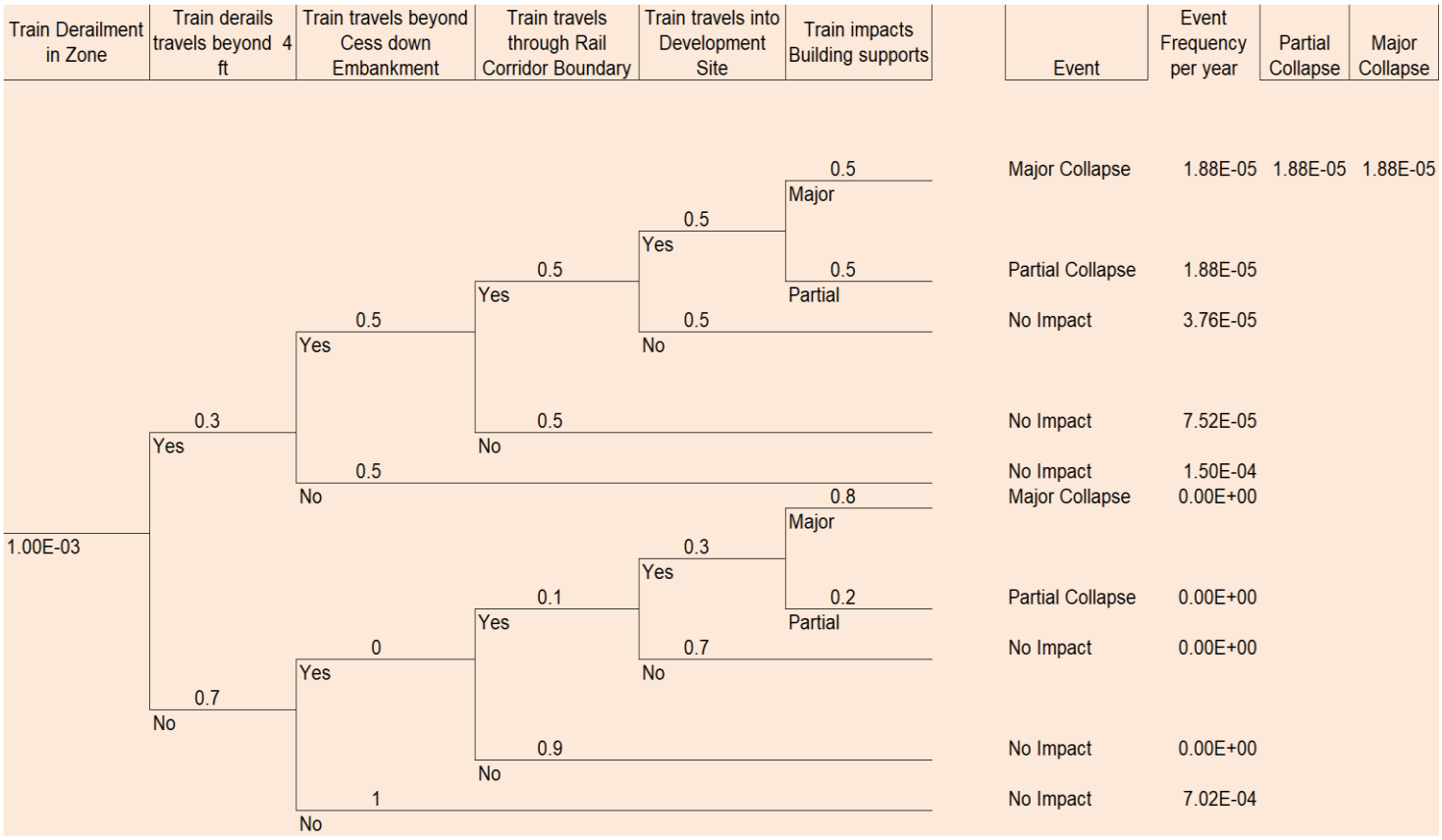


The generic frequency of derailment per train km per year on the open Sydney Trains Network is modified in this analysis on the basis of the site specific derailment hazards as shown above.

5.6 EVENT TREE ANALYSIS

The units of the frequency analysis have been transformed from per train movement km to per train movement via the study area by the application of a train length track of interest equivalent to the braking distance at the platform approach track speed. As a consequence, the Train Derailment Frequency in the Zone (first column) is smaller than the reported Site Specific Derailment Frequency in the Fault Tree. The results are incorporated in the Train Collision Analysis of the following section.

DOWN LOCAL WORKING	**Passenger**		**Total**
BARRIER TO ACT AS PROTECTION	Nil		⇒
1. Passenger Line Derailment Frequency	1.09E-07	per movement	
2. Train Movements per lines	46080	per year	To Derailment
3. Per Study Length (Derailment Zone)	0.2	km	Risk Assessment
4. Total Derailment Frequency	1.00E-03	per year =(1*2*3)	1.00-03



5.7 TRAIN COLLISION ANALYSIS

The frequency of a single train collision is then estimated as:

- Line Frequency = Frequency in Study Zone / Passenger movements per year

Thus for passenger trains on the Down Local Working:

- Partial Collapse = 1.88 E-05 / 46,080 = 4.08E-10

Applying this to the Down Local West Line and major collapse scenario we have:

Passenger Movements	*Down Local West*
Partial Collapse	4.08E-10
Major Collapse	4.08E-10
Total	8.16E-10

To Individual Risk (Fatality)

5.8 FATALITY RISK per YEAR

5.8.1 Individual Risk

In the event of an incident, the risk to an individual is a function of the probability of fatality per incident, based upon groups and numbers of persons potentially exposed to the incident frequency and train movements. The number of individuals at risk is calculated from:

(Train movements x Probability of Fatality x Probability of Exposure)
x passenger movements

For a building structure such as the proposed combined commercial and residential development the probability of fatality has been estimated at 0.8 for an exposed commuter in a train when a multi-storey building collapses on it, and the probability of exposure of train occupants as 0.125 (1car per 8 car set) for a partial collapse and 0.250 for a major collapse. A commuter will undertake 2 trips per day (to and from work), 5 days per week, for 52 weeks minus 4 weeks holidays, that is (2 x 5 x 48) = 480 trips per annum.

Thus Daily Commuters risk per annum = (Partial Collapse Freq x Prob Fatality Multistorey Collapse x Prob Exposure) + (Major Collapse Freq x Prob Fatality Multistorey Collapse x Prob Exposure) x Passenger Trips

= ((4.08-10 x 0.8 x 0.125) + (4.08E-10 x 0.8 x 0.25)) x (480) = 5.87E-08

Applying this to the individuals at risk we have:

Individual Risk (Fatality) Per Annum

Passenger Movements		
Daily Commuter	5.87E-08	
Train Driver/Guard	5.87E-08	
Casual Commuter (off-peak 35% trips)	1.22E-08	
Building Occupant	4.74E-07	per year
Tolal	6.03E-07	per year

The frequency of a fatal incident is then calculated for partial and major collapse scenarios for which incident frequency has been estimated on the Event Trees for both peak (35%) on off-peak (65%) services. For instance:

- Down Local Partial Collapse during Peak Services
  = 1.88E-05 x 35% = 6.58 E-06

Applying this for both Partial and Major Collapse scenarios during peak and off-peak services we have:

Passenger Movements	***Down Local West***
Peak - Partial Collapse	6.58E-06
Peak - Major Collapse	6.58E-06
Off-Peak - Partial Collapse	1.22E-05
Off-Peak - Major Collapse	1.22E-05
per year	3.76E-05
Equivalent a fatal incident every	26,598

5.8.2 Societal Risk

The societal risk can be assessed by assuming a range of exposures for persons in trains and persons in and around the building development. Thus in the case of a Partial Collapse during peak services the number of persons exposed to potential fatality may be calculated from:

- Number of passengers per carriage x 8 cars x probability of Exposure to Partial Collapse x Probability of Fatality

For peak loads this equates to:

- 210 passenger x 8 cars x 0.125 (1 car per 8 car set for partial collapse) x 0.5 (multi-storey structure strikes train) x 0.2 (Probability of Fatality) = 21

And for off-peak based up to 25 commuters per carriage, while for the residential units (up to 12 levels) in the case of partial collapse we have:

- (20 persons in apartments facing the rail line) x 0.125 (likelihood strike by partial collapse) x 0.4 (multi-storey structure) = 1

Applying this for both Partial and Major Collapse scenarios during peak and off-peak services we have:

	Potential Number Persons Exposed in the environ or vicinity of an incident:		
Societal Risk- Scenarios	Train	Development	Total
Passenger Movements			
Peak - Partial Collapse	21	4	22
Peak - Major Collapse	42	8	44
Off-Peak - Partial Collapse	2.5	1	4
Off-Peak - Major Collapse	5	2	7

By multiplying the fatal incident frequency by societal risk provides a profile of the risk exposure of different individuals:

Scenario	**Passenger Movements**	
Partial Collapse - Train Fatalities - Peak	1.38E-04	22.2%
- Train Fatalities - Off-Peak	3.05E-05	4.9%
- Building Fatalities - Peak	2.63E-05	4.2%
- Building Fatalities - Off-Peak	1.22E-05	2.0%
Major Collapse - Train Fatalities - Peak	2.76E-04	44.4%

- Train Fatalities - Off-Peak	6.11E-05	9.8%
- Building Fatalities - Peak	5.26E-05	8.5%
- Building Fatalities - Off-Peak	2.44E-05	3.9%
Total Potential Loss of Life per year	6.22E-04	100.0%
Equivalent to a Potential Loss of Life every	1,608	years

5.9 RISK ASSESSMENT

5.9.1 Base Case

Total Derailment Frequency over study area (ref section 5.6) is 1.00 -03 per year, equivalent to a derailment every 997 years.

The risk analysis estimates a potentially fatal individual incident consequence to a derailed train striking the building at 3.76E-05 per annum (section 5.8.1) = a fatal incident scenario every 26,598 years with a potential impact on 2 to 44 persons exposed in the train and building in the event of a derailed train striking the building.

The fatal incident frequency and number of persons potentially exposed has been applied to estimate a Societal Risk, expressed as a Potential Loss of Life (PLL) per year, and this has been estimated as 6.22E-04 persons (section 5.8.2). This equates to a PLL every 1,608 years.

The qualitative assessment (see Appendix A) has applied the societal PLL scenario. In the SMS TERM as specified in T-HR-CL-12080-ST this equates to a worse case of multiple fatalities (C1) less than once every 100 years (L6) that equates to a isk level of 'C' given the almost unprecedented likelihood of such an event (see risk matrix section 3.4).

5.9.2 Scenario Testing – Increased Traffic

Scenario testing has been undertaken of increased traffic densities, with two test scenes of current (base) traffic increasing by 1.5 times and then 2x existing frequencies:

	Traffic Density		
	Current	Current x 1.5	Current x 2
Derailment Incident every	997 years	665 years	499 years
Societal risk considering the number and categories of persons exposed PLL every	1,608 years	1,072 years	804 years

The results indicate that an increase in rail traffic to an upper limit of line capacity results in a potential loss of life normalised to once every 804 years, which in the risk matrix still equates to worse case multiple fatalities (C1) less than once every 100 years (L6) and a risk ranking of 'C'.

5.9.3 Cost of Risk Reduction

Given that guard rails (most effective protection maintaining inner derailed wheels within 4ft and outer within cess), the further potential risk reduction measures on the section of track adjacent the development site would involve construction of a deflection wall, or provision of derailment impact resistance in the building structures. The deflection wall is a preferred measure to avoid impact, while reinforcing the building support structures is a measure intended to reduce the impact of a collision subsequent to a derailment.

For the purpose of testing this scenario the potential number of persons exposed has been estimated as follows:

	Potential Number Persons Exposed in the environ or vicinity of:		
Societal Risk- Scenarios	Train	Development	Total
Passenger Movements			
Peak - Partial Collision	4	1	5
Peak - Major Collision	8	2	10
Off-Peak - Partial Collision	1	1	2
Off-Peak - Major Collision	4	2	6

This figure has been analysed as previously and the results are:

- Societal Risk Base Case 6.22E-05 PLL per year
- Societal Risk with Impact Wall 1.96E-05 PLL per year
- Resultant Risk Reduction 4.26E-04 per year

The justified level of expenditure on such risk mitigation measures is based upon the value of Implied Cost of Averting a Fatality (ICAF) for which a current life insurance value is taken as $6M:

Justified Expenditure = ((Risk Reduction x Life Expectancy of Measure) / Benefit:Cost Ratio attributable to the Measure)) x ICAF
= ((4.26E-04 x 20 years) / 0.5 BCR)) x $6,000,000
= $102,133

The cost of this risk reduction is considered proportionate to the potential cost of preventative and/or mitigation measures and the safety benefits that may be derived for structures located less than 10m from the adjacent Down Local Line.

6. CONCLUSION

The existing track profile on the approach to the proposed residential building development at 2 Pilgrim Ave, Strathfield is consistent with the fact that:

- Track is configured and maintained fit for purpose for the speeds currently placed on the individual lines as per Train Operating Conditions Manual
- Current risk profile from hazards of a derailment or collision impacting commuters is managed ALARP
- In order to comply with SFAIRP additional impact prevention or resistance shall be prescribed in accordance with AS5100 requirements

The most likely incident scenarios are:

- Derailment incident once every 997 years
- Derailment leads to fatal incident every 26,589 years as a consequence of the building development
- Societal risk considering the number and categories of persons exposed in train and building as a consequence of derailment during a fatal incident impacting 4 to 44 persons normalises to a Potential Loss of Life, once every 1,608 years

The desk-top qualitative assessment in Appendix A is based upon the likelihood of a derailment and subsequent collision with a building support of less than once every 100

years, and a consequence of the impact of worse case of multiple fatalities resulting in a risk ranking ‘C’.

In accordance with T-HR-Cl-12080-ST and the link to AS5100, the risk assessment and qualitative ranking in the TERM risk matrix indicate that:

- Additional (Rail) Collision Loading Requirement for the support structures of the building located over 10m from the adjacent the rail line as indicated in this report is ‘Nil’

These design specifications are practical, and in accordance with relevant regulations, standards and guidelines, and thereby comply with the requirement to manage derailment risk So Far As Is Reasonably Practicable (SFAIRP).

APPENDIX A – HAZARD AND RISK WORKSHEETS

Hazard Information			Existing Risk Controls	Original Risk			Proposed Additional Risk Control	Residual Risk			
Hzd Ref.	**POTENTIAL CAUSES**	**POTENTIAL CONSEQUENCES (Worse Case)**	**CONTROLS**	**Likelihood**	**Consequence**	**Risk**	**ADDITIONAL CONTROLS**	**Likelihood**	**Consequence**	**Risk**	**COMMENTS**
	SCENARIO 1 – 10m OFFSET: STRUCTURAL COLLAPSE OF BUILDING OVER TRAIN FOLLOWING:										
1	TRAIN DERAILMENT owing to track condition on Down Local West, derailed train travels: 1. Beyond tracks ie outside 4 ft, thence 2. Beyond cess down embankment 8-10m, and 3. To boundary thence 4. Laterally displaced up to 7m within site boundary of SP 8785 and strikes building supports located further inside the property, approx. 15m from centre line of derailment track	DERAILED TRAIN IMPACTS BUILDING located some 15m from nearest running rail line hence direct impact unlikely, rather effects of shock of derailment Worse case estimates of consequence of derailment travelling beyond rail boundary and base of embankment 1 Fatality / 10 Major Injuries	• Track designed to ENGINEERING STANDARDS • Line Speed recommended 50kph, max 80kph, track fit for purpose • Class 1 track (60kg rail) and concrete sleepers • 535 crossover signal ST131 has catchpoint on Down suburban with derailment throw away from Up & Down Locals ie derailed train travelling away from site and no likelihood of impacting buildings • 603 from Down Local to Terminal Road at Homebush Station, a derailed train could not reach site (ref section 4) • Trains terminating on Strathfield Platform 8 shunt on Down Local to Homebush Terminating Platform • West Region (IMG) conducts Inspection / Maintenance in accordance with Technical Maintenance Plans and Works Orders • Line speed / traffic restrictions during floods, noting that track is well drained and ballasted and on minor embankment • WOLO procedures for installing track speed restrictions in hot weather • Building Support Structure located over 10m from running line (Dn Local West boarded at passenger 50kph on approach from Strathfield Station • Operations Rail operations and rollingstock infrastructure referred section 5.2, and consequence of building development is that more persons are potentially exposed such as occupants of the new building • Track Minor curved away from site section of track, concrete sleepered and fit for purpose at indicated track speeds with minor geometric defects managed within tolerance and not posing derailment hazard (section 5.2) • Rollingstock Sydney Trains electric passenger trains as sections 5.2 fit-for-purpose (train operating conditions)	L6	C2	C	Nil on basis that: • Design & configuration of Building complies with Good Practice / Law / Codes of Practice in particular risk analysis as per T-HR-CL-12080-ST cl 6.12 and link ESC380 Table 1, clause 5.13, for specifying AS5100 2017 Collision Loading Requirement for support structures located between 10 to 20 metres from the rail line meets ALARP requirement • Design is Reasonably Practicable On this basis safety is assured So Far As Is Reasonably Practicable (SFAIRP)	L6	C2	C	• Historical records indicate no derailments that would impact development site on record in IIMS or RIC databases since 1998 on this section of line

Hazard Information			Existing Risk Controls	Original Risk			Proposed Additional Risk Control	Residual Risk			
Hzd Ref.	POTENTIAL CAUSES	POTENTIAL CONSEQUENCES (Worse Case)	CONTROLS	Likelihood	Consequence	Risk	ADDITIONAL CONTROLS	Likelihood	Consequence	Risk	COMMENTS
2	REAR-END TRAIN COLLISION causes derailment of leading train that could strike building	DERAILED TRAIN IMPACTS BUILDING located some 15m from nearest running rail line hence direct impact unlikely, rather effects of shock of derailment Worse case estimate of consequence of derailment travelling beyond rail boundary and base of embankment 1 Fatality / 10 Major Injuries	• ST133 L Auto Departure Signal from Strathfield Platform 8 controls access and separation of trains on Down Local travelling to Homebush • ST233L Signal controls separation of trains on Down Local progressing towards Homebush • ST241L Home Signal controls access from Down Local to Local Terminal Road • Fixed Red Lights (12.567) prevents unauthorised crossing of departing trains from Local Terminating Road onto Down Local Line • Building Support Structure located over 10m from running line (Dn Local West boarded at passenger 50kph on approach from Strathfield) • Operations Rail operations and rollingstock infrastructure referred sections 2.2, 3.2, and consequence of building development is that more persons are potentially exposed such as occupants of the new building • Track Straight section of track, concrete sleepered and fit for purpose at indicated track speeds with minor geometric defects managed within tolerance and not posing derailment hazard (section 2.2) • Rollingstock Sydney Trains electric passenger trains as sections 2.2 and 3.2 fit-for-purpose (train operating conditions)	L6	C2	C	Nil on basis that: • Design & configuration of Building complies with Good Practice / Law / Codes of Practice in particular risk analysis as per T-HR-CL-12080-ST cl 6.12 and link ESC380 Table 1, clause 5.13, for specifying AS5100 2017 Collision Loading Requirement for support structures located between 10 to 20 metres from the rail line meets ALARP requirement • Design is Reasonably Practicable On this basis safety is assured So Far As Is Reasonably Practicable (SFAIRP)	L6	C2	C	• Historical records indicate no derailments that would impact development site on record in IIMS or RIC databases since 1998 on this section of line
3	Incidental Causes of DERAILMENT or COLLISION Train on FIRE on track adjacent unit developments	Building located some 15m from nearest running rail line hence direct impact unlikely, rather effects of shock of derailment	• ST133 L Auto Departure Signal from Strathfield Platform 8 controls access to section and separation of trains on Down Local travelling from Strathfield to Homebush Design Fire & Life Safety to comply with appropriate Fire Rating requirements: • BCA minimum fire rating ref egress from building • Also fire rating under Sydney Trains / ASA codes to comply with Sydney Trains / RailCorp obligations under the RSNL 2014 (Rail Safety Act and Regulations) in particular for provision of safe egress for persons on or in vicinity of a ST / RailCorp property or asset	L6	C2	C	Nil on basis that: • Design & configuration complies with relevant codes and standards and SFAIRP achieved on basis that no reasonable alternative available that would reduce level of risk	L6	C2	C	
	HEAT Buckle during hot weather	Worse case estimate of consequence of	• WOLO procedures for installing track speed restrictions in hot weather	L6	C2	C	Nil on basis as per 1 previous	L6	C2	C	

DERAILMENT SCENARIOS on DOWN LOCAL WEST LINE
adjacent RESIDENTIAL DEVELOPMENT at 2 PILGRIM AVENUE, STRATHFIELD

Hazard Information			Existing Risk Controls	Original Risk			Proposed Additional Risk Control	Residual Risk			
Hzd Ref.	POTENTIAL CAUSES	POTENTIAL CONSEQUENCES (Worse Case)	CONTROLS	Likelihood	Consequence	Risk	ADDITIONAL CONTROLS	Likelihood	Consequence	Risk	COMMENTS
	FLOODING during heavy rains	derailment travelling beyond rail boundary and base of embankment 1 Fatality / 10 Major Injuries	Track designed to ENGINEERING STANDARDS • Infrastructure Maintenance conduct Inspection / Maintenance in accordance with Technical Maintenance Plans and Works Orders • Line speed / traffic restrictions during floods, noting that track is well drained and ballasted and on minor embankment	L6	C2	C	Nil on basis as per 1 previous	L6	C2	C	