
# RISK ASSESSMENT

# Derailment Scenarios
# on
# Southern Sydney Freight Line
# adjacent

# Development
# 21 Atkinson Street
# Liverpool

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## DOCUMENT REVISION RECORD

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| Initial Risk Management Report<br>Derailment Scenarios<br>Draft version 0.A<br>For review by stakeholders | David Cotton | 27/06/16 | Andrew Barnett | 27/06/16 | | |
| Initial Risk Management Report<br>Derailment Scenarios<br>Draft version 1.0<br>Following review & revised Architectural Drawings | David Cotton | 25/07/16 | Andrew Barnett | 26/07/16 | | |
| Risk Management Report<br>Derailment Scenarios<br>Draft version 1.1<br>Following review of Xavier Knight 'Retention Wall Design' Report 17/8/2015 | David Cotton | 18/08/16 | Andrew Barnett | 19/08/16 | | |

# Contents

# 1 OVERVIEW

A derailment risk assessment has been undertaken for structures at 21 Atkinson Street, Liverpool located within 10-20m of an adjacent rail track centreline. The study has been conducted in accordance with the Asset Standards Authority (ASA) T-HR-Cl-12080-ST, version 1.0 of February 2015. The purpose is to determine appropriate load requirements specified in AS 5100 as mitigation to manage the risk of collision from a derailed freight train on the adjacent bi-directional Southern Sydney Freight Line. The risk assessment takes into account:

- Site condition (elevation below level of rail line)
- Derailment history (nil records of train derailments or collisions on the section adjacent the development)
- Type of structure and potential for collapse damage to trains and building occupants
- Track geometry (maintained fit for purpose, straight section)
- Track speed (sign board max approach 115kph coasting)
- Type of rolling stock (non electric freight trains)
- Future use and growth and developments

The unit developments do not impact the likelihood of a derailment but do alter the profile of persons at risk by introducing:

- Additional persons exposed in (occupants) and around the buildings
- Additional exposure to freight train crew (driver and observer) in the event of a collapse of a section of the building onto a train following a derailment and collision with a support structure

The **quantitative** risk model analysis for this rail section as a whole estimated:

- Potential derailment incident once every 241 years
- Average derailment frequency 1.70E-07 per train movement
- Fatal incident every 53,466 years (as a consequence of impact with buildings)

The desktop **qualitative** assessment using the specified risk matrix found that:

- Likelihood of a derailment on Up Main = L5 (Very Unlikely)
- Likelihood derailment proceeding to site boundary = L6 (Almost Unprecedented)
- Most likely case consequence following derailment as a result of building 1Fatality – 10-20 Major Injuries = C2 (Severe)
- Risk Level = L6 x C2 = C (Tolerable)

T-HR-CI-12080-ST applies the result of the risk analysis to determine the category of loading requirement from AS 5100 that is to be applied to a support. In accordance with T-HR-CI-12080-ST where the supporting elements are located within 10-20 metres of the rail line they shall comply as per Table 1, clause 5.13, the AS5100 Collision Loading Requirement for support structures:

| Safety Risk Matrix Ranking | AS 5100 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 |

In conclusion, the risk assessment finds that the likelihood of a derailed train travelling and displacing laterally an adequate distance down an embankment to strike and collapse a structural column resulting in fatality and major injuries is less than once in 1,000 years. The consequence is a risk level of 'C' in the TERM risk matrix that is nominated in T-HR-CI-12080-ST. It is noted that given the unprecedented likelihood of an impact, this risk ranking remains 'C' even if more fatalities are factored into a worse case outcome event.

In accordance with this and the link reference to specification in AS5100:

- (Rail) Collision Loading Requirement for the support structures of the buildings adjacent the rail line is 'Nil'.


Furthermore, a derailment on the adjacent Down Main South Line (see diagram section 3.3) would be laterally contained by the SSFL and is a lower risk.

# 2 INTRODUCTION

The development is located in a property adjacent the SSFL previously occupied by Rheem Pool Heating between Liverpool and Casula Stations.

The purpose of this risk assessment is to determine appropriate load requirements of AS 5100 for the unit developments with regards to the risk of collision from a derailed train on the adjacent Up Main West rail line. It is undertaken in accordance with T-HR-CL-12080-ST External Developments Clause 5.13 that applies the risk ranking assessed in the analysis to determine the category of collision loading in AS5100 to be applied to design of supports. This table categorises safety risk rankings and specifies that 'C' and 'D' require nil collision loading requirements in addition to other applicable design requirements in AS5100.

The risk assessment takes into account:

- Site configuration - embankment elevates track above existing industrial building level

- Centreline of nearest rail line to nearest buildings is 11-14m (refer drawings in section 3.2 and Xavier Knight Retention Wall Design Report, 17 August 2016 sections 1.3 and 8.1)
- Track is 60kg railed, bidirectional conveying freight traffic from 385 to 1500-1800 intermodal metre length consists conveying cement, steel, general freight, grain, coals and containers, plus some Diesel Passenger Trains (Xplorer, Endeavour, XPT) as scheduled in ARTC Master Plan, Mar 2016
- Track on approach has no discontinuity components e.g. catchpoints; turnouts (facing or trailing); slips; diamonds; scissor crossovers that would increase the hazard of derailment above the network average during normal operations
- Track is level, rising and falling 1:100 on either approach to the site
- Track is straight adjacent the site and past towards Casula, while curve is gradual away from the site on the Liverpool approach (ie throw of derailed train away form site towards Down Main South line)
- Track speed 110kph board approaching the site (SSFL boarded 110kph to Glenfield, 80kph to Leightonfield)
- Type of rolling stock electric and diesel passenger and freight
- Future usage and growth reviewed in section 4.1
- Derailment history – since commencement of operations in January 2013, no derailments on this section

In summary, the proposed building development will not impact the likelihood of a derailment but may alter the profile of persons potentially at risk by introducing:

- Freight train crew (driver and observer in cab) who may be exposed in the event of a collapse of a building onto a train following a derailment and collision with a building support structure
- Building occupants (max 20 in apartments within 20m facing the SSFL rail line) a given number of whom may be exposed at a given time to a potential impact of a train collision event

The assessment estimates the number of persons in these groups who could be injured following a derailment incident impacting the new building. Event Tree and Collision Analyses (sections 5.7, 5.8) estimate the likelihood of partial and total collapse per train movement that derails and impacts the development structure(s), and the number of persons who could be exposed are then considered in estimating the potential fatalities per train movement.

# 3 BACKGROUND

## 3.1 LOCATION

The development site is adjacent the rail corridor and SSFL section between Liverpool and Casula Stations:


## 3.2 DEVELOPMENT

The development comprises the demolition of the existing warehouse/light-industrial buildings and construction of a part 3, part 7 and part 9 storey (8 levels and roof) residential flat building with:

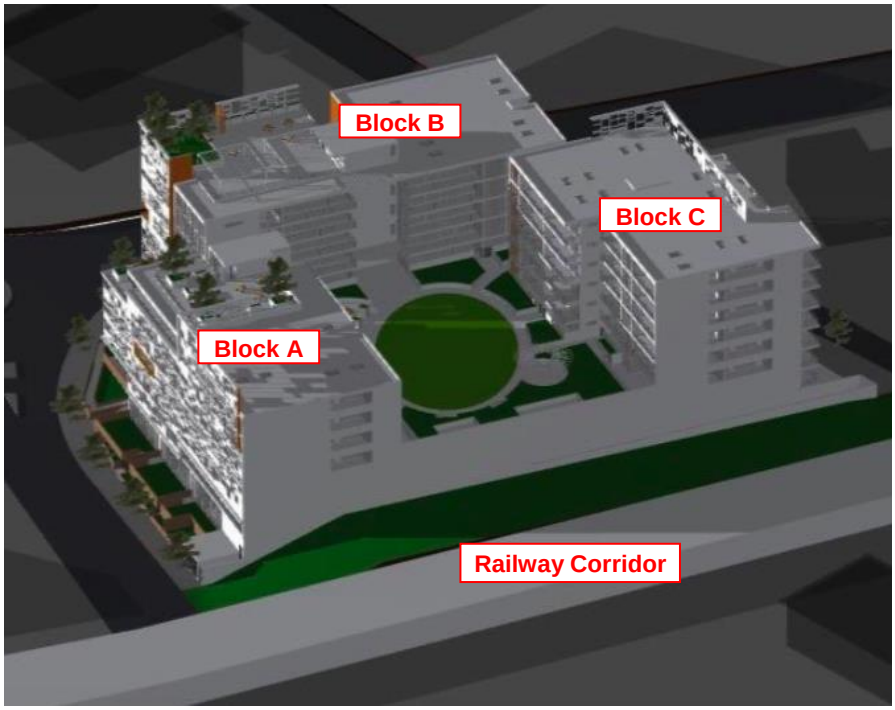
- 1 level of partial basement parking and 2 above ground parking levels
- 143 residential apartments
- 4 neighborhood shops are situated at the south-eastern corner of the site

Third floor and above comprises three tower buildings, blocks A, B and C, arranged around a large, centrally located communal open space area.

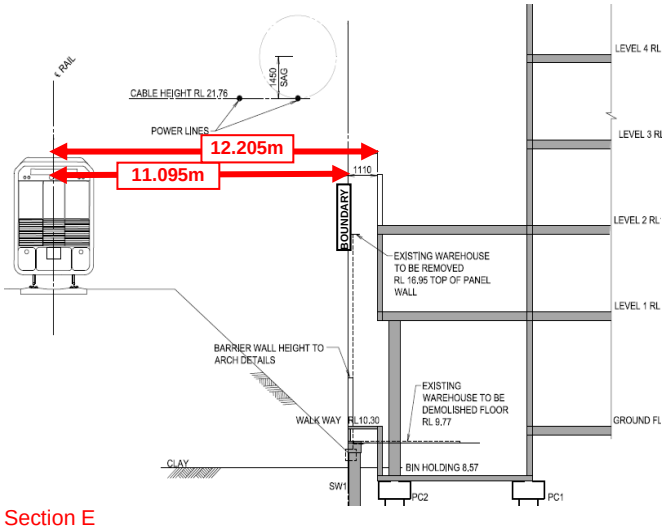
Block A is 4 storeys above podium and Blocks B and C are each 7 storeys above podium.

A roof top communal open space area is provided at the north-eastern corner of Block A and at the rooftop of Block B. From third floor and above, the development delivers 20 x 1 bedroom, 82 x 2 bedroom and 11 x 3 bedroom dwellings.

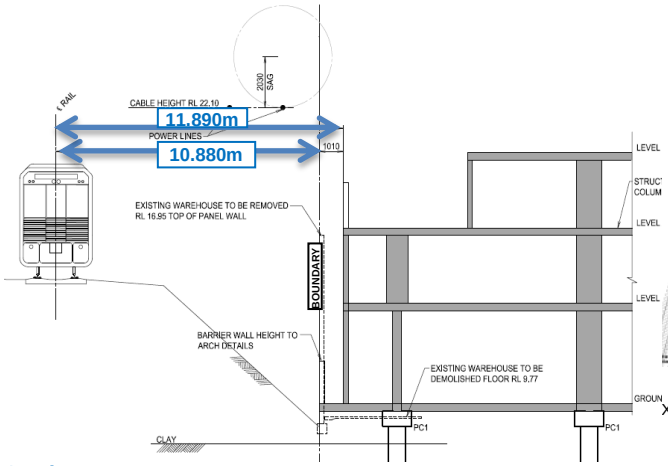
The following is a perspective of the development fronting the SSFL:



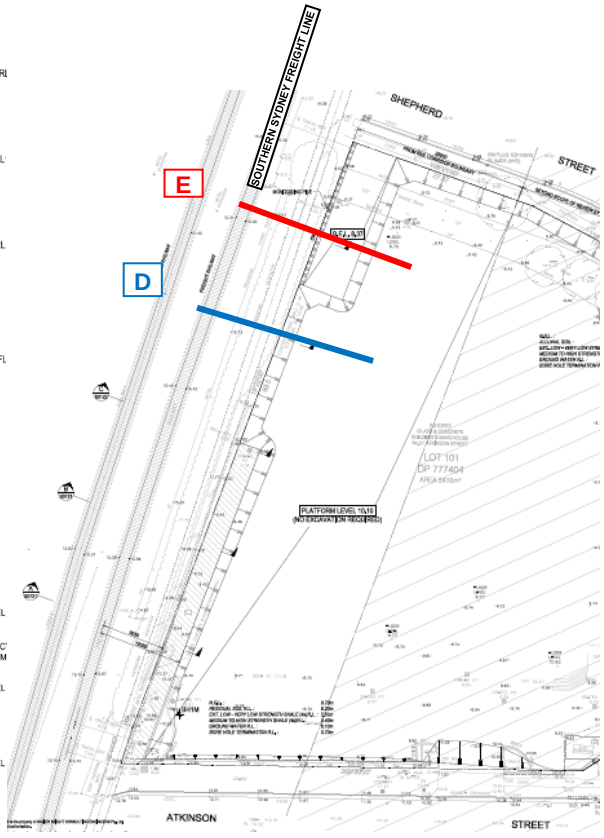

Xavier Knight Structural Engineers – Rail Corridor Section Drawings S0101 building shoring and earthworks plan indicates configuration clearances as follows:



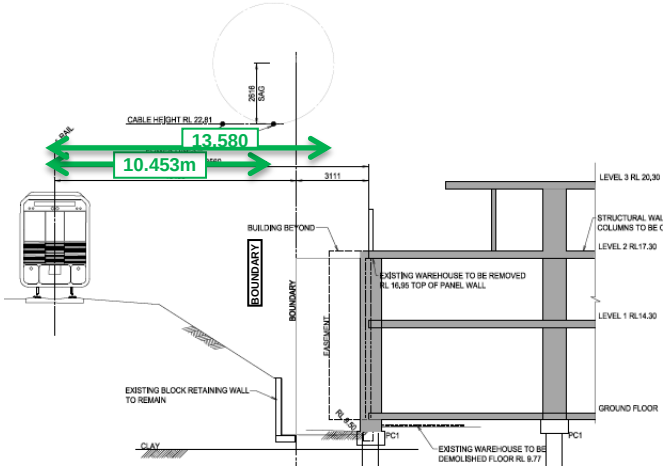

Section E



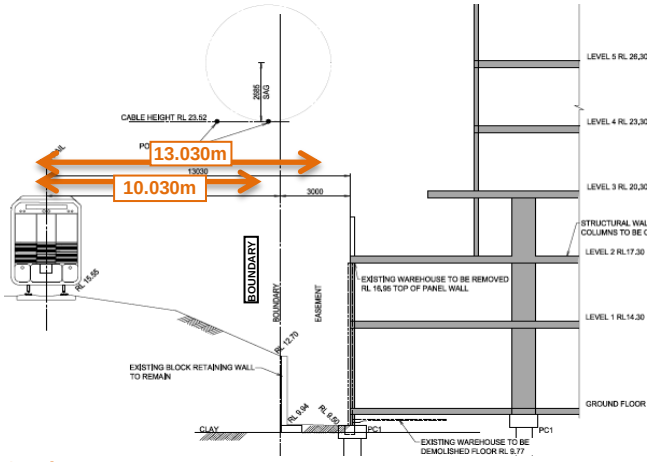

Section D



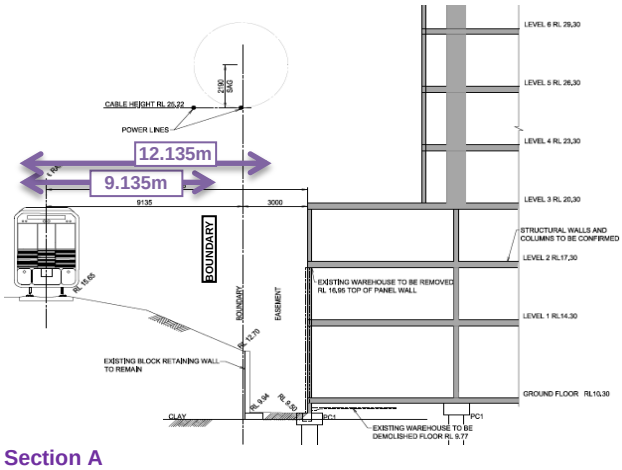

Xavier Knight Structural Engineers – Rail Corridor Section Drawings S0101



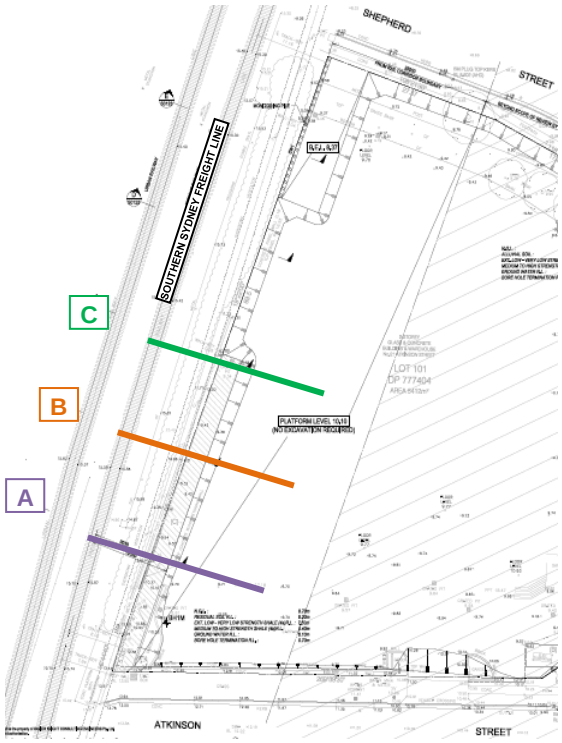

**Section C**




**Section B**



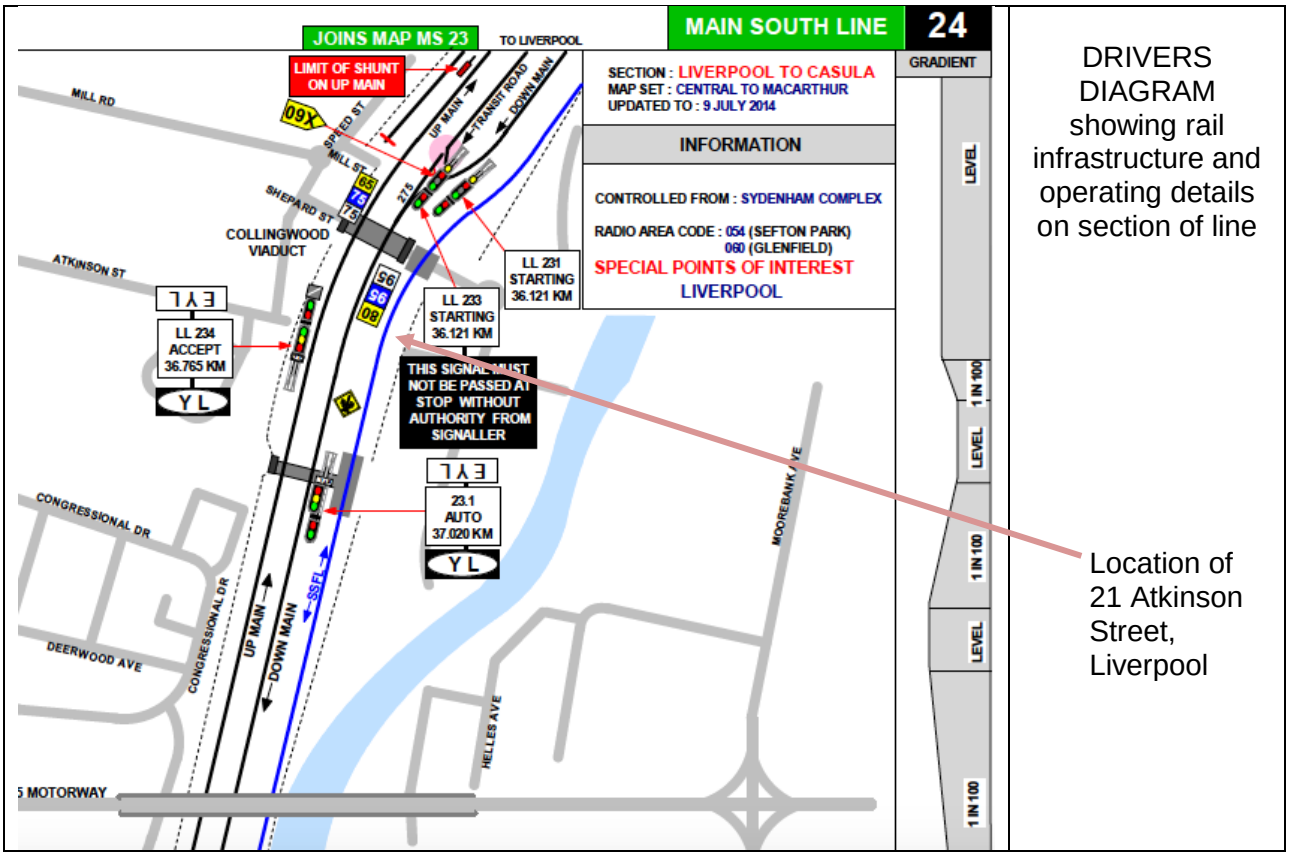

**Section A**




Xavier Knight Structural Engineers – Rail Corridor Section Drawings S0101

## 3.3 TRAIN DRIVERS DIAGRAM

The drivers diagram shows the track infrastructure and operating conditions – SSFL in blue:




DRIVERS DIAGRAM showing rail infrastructure and operating details on section of line

Location of 21 Atkinson Street, Liverpool

# 4 RISK ASSESSMENT METHODOLOGY

## 4.1 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 and Subject Matter Experts and reference to clauses in Engineering Standard T-HR-CL-12080-ST External Developments.

## 4.2 STAKEHOLDERS & SUBJECT MATTER EXPERTS

Information has been sourced from:

ARTC, Discussion with Michael Walsh, ARTC Sydney Operations

- No freight train derailment or collision incidents on this section since commissioning into operation in January 2013

Rail Infrastructure Corporation Incident Database reviews 1998-2004:

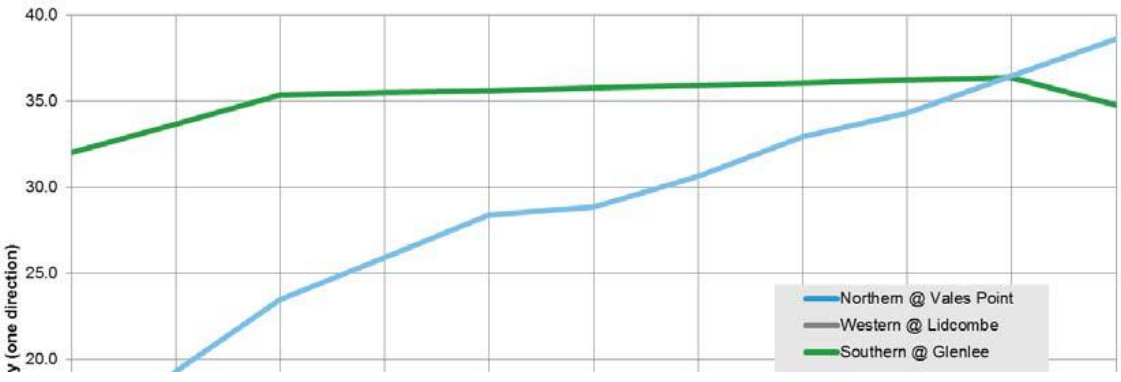
- Liverpool during possession shunting derailed at points to shed (9/1/1993) – note this would have no impact on site being analysed in this study, and furthermore the section under review in this study is straight rail with no points ie this scenario does not exist)
  Only other incidents involved loose skirting on wagon demolished signal at Liverpool (24/10/1994); signal points relay box damaged by rolling stock at Liverpool (10/7/1997); train struck by object at Casula (9/11/1999); and closest derailment was incident at Sefton Junction points 26/8/2001 (note the section under review in this study is straight rail with no points ie this scenario does not exist)

RailCorp IIMS review 2004-2013 and Sydney Trains 2014-2015:

- No train derailment or collision incidents on the adjacent Down Main South through this section

NSW Freight and Ports Strategy 2015 and ARTC 2015 Sydney Metropolitan Freight Strategy, October 2015

- The SSFL runs 36 kilometres between Sefton Park Junction and Macarthur, linking the Interstate Network between Sydney and Melbourne with the Metropolitan Freight Network (MFN) managed by the ARTC. It provides access to the MFN and Port Botany from the south. Forecast traffic on SSFL from the South is shown in green (Southern @ Glenlee) includes diesel passenger trains



## 4.3 RISK ASSESSMENT

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 |

## 4.4 RISK CRITERIA

In accordance with T-HR-CI-12080-ST and previous T-HR-CL-12080-ST Clause 5.13, the results of the risk analysis will determine the category of collision loading in AS 5100 that is to be applied to a support. The risk ranking determined from the risk analysis shall be equated to a loading requirement from AS 5100 as tabulated below:

| Safety Risk Matrix Ranking | AS 5100 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 |

# 5. DERAILMENT RISK

## 5.1 DATA and INFORMATION

The Incident Information Management System has no recorded derailment or collision incidents since 1998 at this section of the Main South Line that would impact the proposed development, and information from ARTC indicates no derailment incidents on the SSFL since it was commissioned into operation in January 2013.

## 5.2 RISK ASSESSMENT

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

- Site Specific Hazards to average on Freight Network (MFN, SSFL)
- Operating Specific Hazards to average on Freight Network (MFN, SSFL)

## 5.3 SITE SPECIFIC FEATURES

The SSFL is concrete sleepered track with 60kg rail and is designed and in a condition to carry the traffic at the speeds indicated (ref ARTC Sydney Operations).

Current freight traffic comprises freight trains 650m to 1500m (40%) and 1800m interstate (approx. 20%)in length with projected traffic 35 trains per day in one direction, Taking account of closedowns on the line that equates for up to 15 days per annum, this gives:

= (35 x 2 x 350) = 24,500 freight services per year

| ***Line*** | SSFL |
|---|---|
| Maximum approach speed | 115 |
| Recommended approach Speed (200m) ex Liverpool | 100 |
| Train Status | Coasting |
| Number of Signals on approach | 1 |
| Freight and Diesel Passenger Service Movements per annum | 24,500 |
| ***Infrastructure Features*** | |
| Rail Curvature | Straight through site, curve away on approach from Liverpool |
| Gradient | Level, 1:100 falling/ rising either approach |
| **Facing Points** | 0 |

References for above include:

- Drivers Diagrams – Track Diagram Main South Line, Liverpool – Casula
- Location of Speed Signs Train Operating Conditions (TOC)

## 5.4 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 Main West Line that would impact he development.

## 5.5 ROOT CAUSE ANALYSIS

The fit for purpose condition of the track was confirmed by Regional Track & Civil Maintenance who indicated that the track in this section is concrete sleepered with 60kg rail, with no derailment incidents and a track that is maintained fit for purpose. The incident review was used to modify the Generic Network Incident Count sample to reflect Site Specific hazards as follows:

**Hazard Area Environmental Factors:**

| ***SSFL*** | Historical Frequency per Train Movement Km | Site Factor * | Total |
|---|---|---|---|
| **FREIGHT & DIESEL PASENGER TRAFFIC** | | | |
| Spread road | 4.27E-07 | 1 | 4.27E-07 |
| Vandalism | 2.05E-08 | 1 | 2.05E-08 |
| Heat buckle | 6.14E-08 | 1 | 6.14E-08 |
| Rock or fill on line | 3.41E-09 | 0.1 | 3.41E-10 |
| Subsiding Embankment | 3.41E-09 | 1 | 3.41E-09 |
| | | | 5.12E-07 |

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

**Hazard Area Infrastructure Factors:**

| ***SSFL*** | Historical Frequency per Train Movement Km | Site Factor * | Total |
|---|---|---|---|
| **FREIGHT & DIESEL PASSENGER TRAFFIC** | | | |
| Broken Rail | 3.75E-08 | 1 | 3.75E-08 |
| Broken Joints | 5.46E-08 | 1 | 5.46E-08 |
| Geometry Design | 3.41E-09 | 1 | 3.41E-09 |
| Excessive Speed | 6.83E-09 | 0.5 | 3.41E-09 |
| | | | 9.90E-08 |

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

**Hazard Area Rolling stock and operational hazards:**

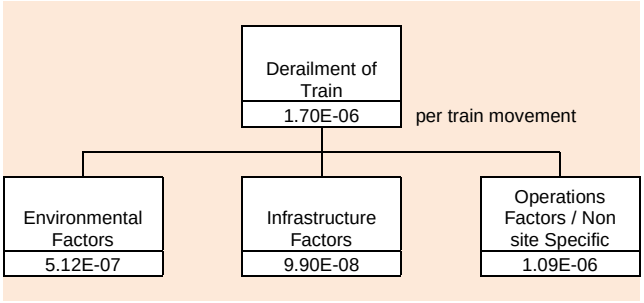
Rolling stock and operational hazards have been assumed to be consistent across the network and have not been modified for line or site specific factors as follows:

| | | Historical Frequency per Train Movement Km |
|---|---|---|
| Operations and Rolling Stock Dependant Hazards | Private Party | 2.90E-07 |
| | Crew performance | 2.35E-07 |
| | Related maintenance work | 1.30E-07 |
| | Faulty brakes | 2.05E-08 |
| | Screwed journal | 1.19E-07 |
| | Scaled wheels | 4.44E-08 |
| | Train - track dynamics (not compatible) | 2.05E-08 |
| | Faulty Wheels | 3.07E-08 |
| | Irregular alignment | 2.73E-08 |
| | Bearer clearance incorrect | 1.71E-08 |
| | Incorrect dampening | 2.73E-08 |
| | Uneven loading | 1.71E-08 |
| | Broken equipment falling | 1.02E-08 |
| | Dragging gear | 6.83E-09 |
| | Faulty coupler | 1.37E-08 |
| | Faulty axles | 1.02E-08 |
| | Jammed axle box | 1.02E-08 |
| | Driver performance | 1.02E-08 |
| | Employee performance | 0.00E+00 |
| | Lashings Loose | 6.83E-09 |
| | Operator performance | 6.83E-09 |
| | Worksite protection | 1.02E-08 |
| | Broken springs | 3.41E-09 |
| | Cracked bogie frame | 0.00E+00 |
| | Damaged rolling stock | 3.41E-09 |
| | Damaged structure | 3.41E-09 |
| | Faulty King Pin | 0.00E+00 |
| | Irregularity released ground frame | 3.41E-09 |
| | Outside agent | 3.41E-09 |
| | Structure collapse | 3.41E-09 |
| | | 1.09E-06 |

## 5.6 FAULT TREE ANALYSIS

The site specific frequency of derailment within the nominated track profile adjacent the support structures of the development adjacent the rail corridor between Westmead and Wentworthville Stations is illustrated on fault trees:

**SSFL FREIGHT & DIESEL PASSENGER TRAFFIC**



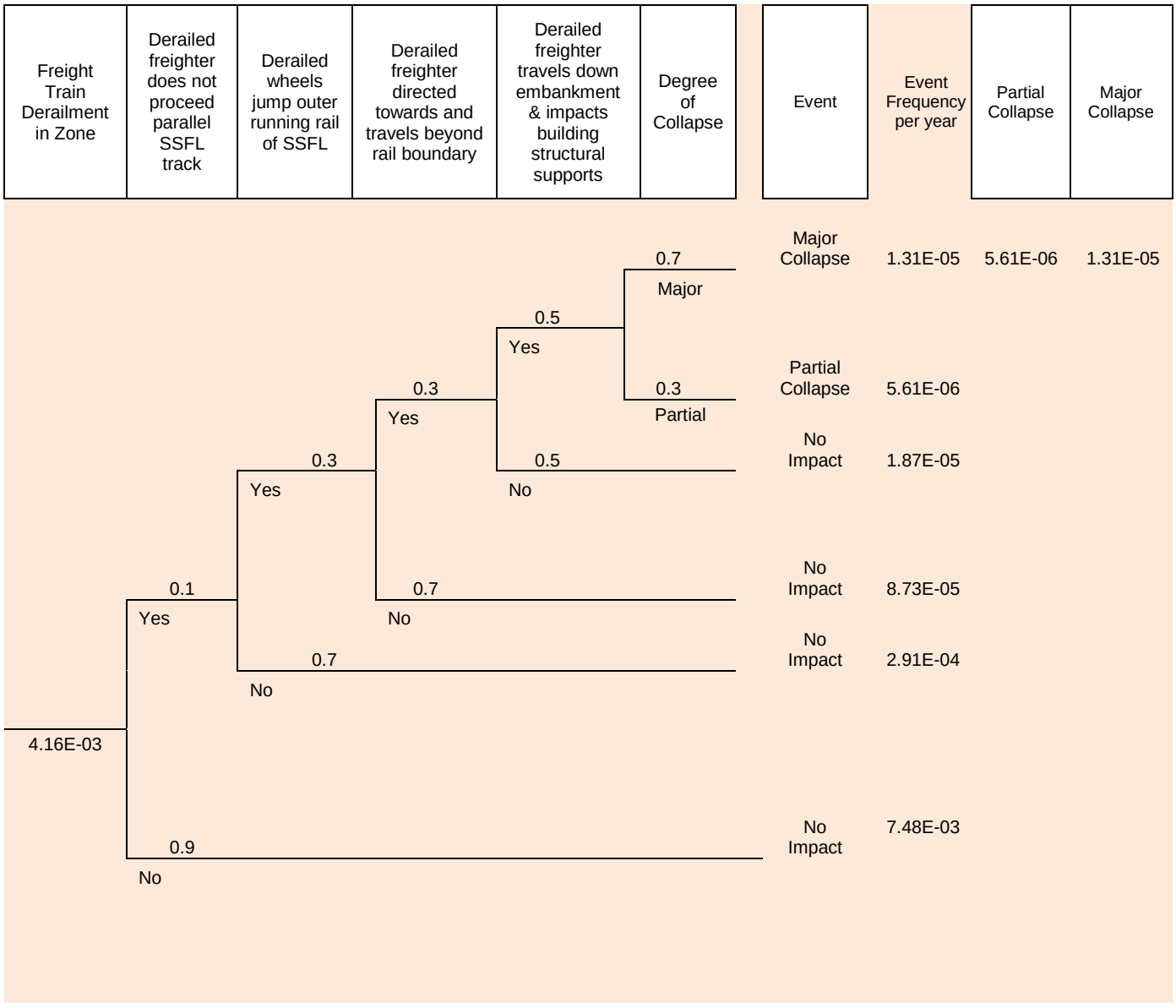

Thus the generic frequency of derailment of 1.09E-06 per freight train km per year on the open metropolitan freight network has been modified on the basis of the site-specific derailment hazards to 1.70E-06 per train km per year for freight traffic on the SSFL on the approaches and adjacent the development site..

## 5.7 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 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 worse case scenario is estimated as follows:

### *Freight Trains*

| *Track Features* | **SSFL** | |
|---|---|---|
| DEFLECTION WALL | *No* | |
| Freight Line Derailment Frequency | 1.70E-06 | per movement |
| Freight Movements | 24,500 | per year |
| Per Study Length (Derailment Zone) | 0.1 | km |
| Total Derailment Frequency | 4.16E-03 | per year |



## 5.8 TRAIN COLLISION ANALYSIS

In the event of an incident, the risk to an individual is a function of the probability of fatality per incident is estimated as:

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

Thus for freight trains on the SSFL:

- Major Collapse = 1.31E-05 (ex Event Tree) / 24,500 (sect 5.3) = 5.34E-10
- Partial Collapse = 5.61E-06 (ex Event Tree) / 24,500 (sect 5.3) = 2.29E-10

Applying this to the SSFL and major collapse scenario we have:

| **Freight & Diesel Passenger Movements** | | |
|---|---|---|
| Partial Collapse | 2.29E-10 | per movement |
| Major Collapse | 5.34E-10 | per movement |
| | 7.63E-10 | |

## 5.9 FATALITY RISK per YEAR

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:

(Frequency Collapse x Probability of Fatality x Probability of Exposure) x Train Movements)

For a structure such as the residential development the probability of fatality has been estimated at 0.4 for a driver or observer in the train cab when a structure collapses on the train and the probability of exposure is 0.125 for a partial collapse and 0.25 for a major collapse. The probability of exposure to either scenario is 0.1. A train (path) is available 2 trips per day (up and down), 5 days per week, for 52 weeks minus 4 weeks possessions and track outages, that is (2 x 5 x 48) = 480 train paths utilisation by nominated trains per annum.

Thus daily risk per annum:

(Major Collapse Freq x Prob Fatality Multistorey Collapse x Prob Exposure to Fatality x Probability Exposure to Event) + (Partial Collapse Freq x Prob Fatality Multistorey Collapse x Prob Exposure to Fatality x Probability Exposure to Event)) x Train Movements on SSFL

= ((5.34E-10 x 0.4 x 0.250 v 0.1) + (2.29E-10 x 0.8 x 0.125 x 0.1)) x 480 = 3.11E-09

Applying this to the categories of individuals at risk we have:

***Individual Risk (Fatality) Per Annum***

| **Freight Movements** | | |
|---|---|---|
| Train (Loco) Driver | 3.11E-09 | per year |
| Building Occupant | 7.24E-07 | per year |

The frequency of a fatal incident has been calculated for partial and major collapse scenarios for which incident frequency has been estimated on the Event Trees (section 5.4) for both peak (35%) on off-peak (65%) services. For instance:

- Up Main West Line Partial Collapse during Peak Services = 5.61E-06 x 35% = 1.96E-06

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

| **Freight Movements** | Fatal Incident Frequency | |
|---|---|---|
| Peak - Partial Collapse | 1.96E-06 | |
| Peak - Major Collapse | 4.58E-06 | |
| Off-Peak - Partial Collapse | 3.65E-06 | |
| Off-Peak - Major Collapse | 8.51E-06 | |
| | 1.87E-05 | *per year* |

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

- Number of person exposed in train x probability of Exposure to Partial Collapse x Probability of Fatality

For freight trains:

- 2 persons in driver cab x 0.5 (building partial collapse on train) x 0.2 (Fatality) = 0.2, say 1 train cab occupant

While for persons in the building who could be impacted in the case of partial collapse we have:

- (20 persons exposed in the building) 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: | | |
|---|---|---|---|
| ***Societal Risk***- Scenarios | Train | Development | Total |
| **Freight Movements** | | | |
| Peak - Partial Collapse | 1 | 1 | 2 |
| Peak - Major Collapse | 1 | 2 | 3 |
| Off-Peak - Partial Collapse | 1 | 1 | 2 |
| Off-Peak - Major Collapse | 1 | 2 | 3 |

By multiplying the fatal incident frequency by societal risk we can see that the highest risk exposure will be to train passengers during the peak:

| Scenario | | Risk Contribution |
|---|---|---|
| **Freight Movements** | | |
| Partial Collapse - Train Fatalities - Peak | 3.93E-07 | 2.9% |
| Partial Collapse - Train Fatalities - Off-Peak | 7.29E-07 | 5.4% |
| Partial Collapse - Bridge Fatalities - Peak | 7.36E-07 | 5.4% |
| Partial Collapse - Bridge Fatalities - Off-Peak | 5.47E-07 | 4.0% |
| Major Collapse - Train Fatalities - Peak | 1.83E-06 | 13.4% |
| Major Collapse - Train Fatalities - Off-Peak | 3.40E-06 | 25.0% |
| Major Collapse - Bridge Fatalities - Peak | 3.44E-06 | 25.2% |
| Major Collapse - Bridge Fatalities - Off-Peak | 2.55E-06 | 18.7% |
| Total Potential Loss of Life per year | 1.36E-05 | 100.0% |

## 5.10 RISK ASSESSMENT

It has been estimated a derailment could occur once every 241 years, and following such an incident, the consequences analysed in the Event Tree forecasts that:

- A derailed loco hauled train is most likely to proceed along the track parallel the site because:
  - The track is straight parallel the site, and on the approach from Liverpool curves slightly away towards the adjacent Down Main South Line
  - the track is fit for purpose, and maintained fit for purpose, is continuous with no signal catchpoints, crossovers or other discontinuities that are potential causes of derailment following a train passing its limit of authority (SPAD) or owing to track deterioration
  - the Fault Tree indicates the most likely cause is a Rollingstock fault, and these most commonly occur with wagons eg cracked wheels, and in locos tend to ‘drag’ these derailed wagons in the consist without derailing the locos eg GM Freight Network Efficiency, Freight & Regional Development, TfNSW, advised of freight incident at Wolli Creek in September 2011 when a hopper door on a coal train dislodged under a wheel resulting in a derailment and damaged infrastructure – but the derailed wagons remained within the cess; confirmed by Asset Engineer, Track, T4 (Illawarra) Asset Planning & Performance, confirmed derailment of freight train owing to hopper door falling off under wheel, and that train on the Up Illawarra Local remained contained between the tracks with subsequent damage to track

The event of a train actually ‘jumping’ the outer rail of the SSFL, crashing through the signal troughing (GST) and beyond the rail boundary thence down the embankment and actually impacting with building support structure and incurring fatalities has been assessed in the Collision Analysis as a possible occurence every 53,466 years.

Thus, in the qualitative assessment (see Appendix A), applying the scenario of a fatality every 53,488 years – in the SMS TERM as specified in T-HR-CL-12080-ST this is rated as1 person (C2) less than once every 1,000 years (L6) from train occupants and persons in and about the new buildings, that equates to a risk level of ‘C’.

# 6. CONCLUSION

The existing SSFL track profile on the approach to the unit developments at 21 Atkinson Street, Liverpool is consistent with the fact that:

- Track is configured and maintained fit for purpose for the speeds currently placed as per Train Operating Conditions Manual
- Current risk profile from hazards of a derailment or collision is managed As Low As Reasonably Practicable (ALARP)

The hazard scenarios have been quantitatively estimated as:

- Derailment incident once every 241 years
- Average derailment frequency 1.70E-07 per train movement
- Fatal incident every 53,466 years (as a consequence of development)

The desk-top qualitative assessment in Appendix A is based upon the llikelihood of a derailment once every 100 - 1,000 years and subsequent collision with building support less than once every 1,000 years and a consequence of impact with building of 1 fatality and/or 10 major injuries, giving a risk ranking ‘C’ – given the unprecedented likelihood of an impact, this risk ranking remains ‘C’ even if more fatalities are factored into the outcome event.

Then design specifications that comply with T-HR-CI-12080-ST and AS5100 practices and code will manager the risk So Far As Is Reasonably Practicable (SFAIRP). These specifications are based upon the risk assessment and qualitative ranking in the TERM risk matrix and indicate that:

- Based upon risk assessment of ‘C’ for likelihood and consequence of derailed train impacting building structures then AS5100 the additional (Rail) Collision Loading Requirement for the support structures of the building adjacent the rail line is ‘Nil’

# 7. APPENDIX A – HAZARD AND RISK WORKSHEETS

Based upon conversations with Stakeholders and SMEs and historical incident data records and information eg IIMS

| 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** |
| | **STRUCTURAL COLLAPSE OF BUILDING OVER TRAIN FOLLOWING:** | | | | | | | | | | |
| **1** | **<u>TRAIN DERAILMENT</u>** owing to track condition on SSFL, derailed train travels:<br><br>1. Beyond tracks ie outside 4 ft, thence<br>2. Beyond cess, GST and boundary, thence<br>3. Down embankment to nearest structures thence<br>4. Strikes building supports located at min 11m from centre line of SSFL | **<u>DERAILED TRAIN IMPACTS BUILDING</u>** located between 11-14m from centre line of SSFL on the embankment; hence direct impact causing structural collapse of multi storey building unlikely.<br><br>Most likely case estimate of consequence of derailment travelling beyond rail boundary and base of embankment is 1 Fatality / 10 Major Injuries | • Track designed to ENGINEERING STANDARDS<br>• Line Speed @ 115/100kph between Liverpool and Casula stations<br>• Class 1 track (60kg rail) and concrete sleepers<br>• No structure (crossovers, catchpoints) in track on approach to site<br>• Signal headway designed for line speeds<br>• No points, crossovers or catchpoints that would direct derailed train towards site<br>• No shunting on this section of track<br>• Inspection / Maintenance conducted in accordance with Technical Maintenance Plans and Works Orders, track fit for purpose<br>• Line speed / traffic restrictions during inclement weather, noting that track is well drained and ballasted on an embankment<br>• WOLO procedures for installing track speed restrictions in hot weather<br>• Building<br>Support Structure located at least 16m from SSFL running line<br>• Operations<br>Rail operations and rollingstock infrastructure referred section 5.3, and consequence of building development is that more persons are potentially exposed such as occupants of the new building<br>• Track<br>Curved section of track away from site on approach from Liverpool, straight through site and thence to Casula, concrete sleepered and fit for purpose at indicated track speeds<br>• Rollingstock<br>Freight with some diesel passenger trains scheduled | **L6** | **C2** | **C** | Nil on basis that:<br>• Design & configuration of Building complies with Good Practice / Law / Codes of Practice in particular risk analysis as per T-HR-CL-12080-ST Table 1, clause 5.13, for specifying AS5100 Collision Loading Requirement for support structures located between 10 to 20 metres from the rail line meets ALARP requirement<br>• Design is Reasonably Practicable<br>On this basis SFAIRP achieved | **L6** | **C2** | **C** | • Historical records indicate no derailments on record in ARTC, IIMS or RIC databases since 1998 owing to infrastructure cause on this section through the site |

| 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 between 11-14m from centre line of SSFL on the embankment; hence direct impact causing structural collapse of multi storey building unlikely.<br>Most likely case estimate of consequence of derailment travelling beyond rail boundary and base of embankment is 1 Fatality / 10 Major Injuries | • Signal headway designed for line speeds; signals on approach to site<br>• Track designed to ENGINEERING STANDARDS<br>• Line Speed @ 115/100kph between Liverpool and Casula stations<br>• Class 1 track (60kg rail) and concrete sleepers<br>• No structure (crossovers, catchpoints) in track on approach to site<br>• No shunting on this section of track<br>• Inspection / Maintenance conducted in accordance with Technical Maintenance Plans and Works Orders, track fit for purpose<br>• Line speed / traffic restrictions during inclement weather, noting that track is well drained and ballasted on an embankment<br>• WOLO procedures for installing track speed restrictions in hot weather<br>• Building<br>Support Structure located at least 16m from SSFL running line<br>• Operations<br>Rail operations and rollingstock infrastructure referred section 5.3, and consequence of building development is that more persons are potentially exposed such as occupants of the new building<br>• Track<br>Curved section of track away from site on approach from Liverpool, straight through site and thence to Casula, concrete sleepered and fit for purpose at indicated track speeds<br>• Rollingstock<br>Freight with some diesel passenger trains scheduled | **L6** | **C2** | **C** | Nil on basis that:<br>• Design & configuration of Building complies with Good Practice / Law / Codes of Practice in particular risk analysis as per T-HR-CL-12080-ST Table 1, clause 5.13, for specifying AS5100 Collision Loading Requirement for support structures located between 10 to 20 metres from the rail line meets ALARP requirement<br>• Design is Reasonably Practicable<br>On this basis SFAIRP achieved | **L6** | **C2** | **C** | • Historical records indicate no rear end collisions on record in IIMS or RIC databases since 1998 owing to infrastructure cause on this section through the site |
| 3 | **Incidental Causes of DERAILMENT or COLLISION**<br>Train on FIRE on track adjacent development | **BUILDING** located between 11-14m from centre line of SSFL on the embankment; hence direct impact causing structural collapse of multi storey building unlikely.<br>Most likely case | Design Fire & Life Safety to comply with appropriate Fire Rating requirements:<br>• BCA minimum fire rating ref egress from building<br>• Also fire rating under Sydney Trains / RailCorp 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 railway property | **L6** | **C2** | **C** | Nil on basis that:<br>• Design & configuration complies with relevant codes and standards and SFAIRP achieved | **L6** | **C2** | **C** | |
| | HEAT Buckle during hot weather | | • 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 SSFL adjacent**
**Development at 21 ATKINSON STREET, LIVERPOOL**

| 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 | estimate of consequence of derailment travelling beyond rail boundary and base of embankment is 1 Fatality / 10 Major Injuries | • Track designed to ENGINEERING STANDARDS<br>• Infrastructure Maintenance conducted Inspection / Maintenance in accordance with Technical Maintenance Plans and Works Orders<br>• Line speed / traffic restrictions during floods, noting that track is well drained and ballasted | L6 | C2 | C | Nil on basis as per 1 previous | L6 | C2 | C | |