Northern Suburbs Transit Corridor

Final Condition Assessment Report

Department of State Growth (TAS)

19 October 2021

→ **The Power of Commitment**

Executive summary

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.2 and the assumptions and qualifications contained throughout the report.

The Northern Suburbs Transit Corridor (the Corridor) consists of the decommissioned railway tracks running from Macquarie Point in the south, through Hobart's Northern Suburbs, to the Glenorchy municipal boundary at the Derwent River in the north. The Corridor largely consists of a single narrow gauge rail line with wooden or concrete sleepers and ballast.

The Government has formed a Northern Suburbs Transit Corridor Working Group to progress the activation of Hobart's Northern Suburbs Transit Corridor. In July 2020, a Northern Suburbs Transit Corridor – Transport Mode Study Options Assessment Report was completed by Price Waterhouse Coopers (PWC). It considered light rail, rapid bus and trackless tram options.

Important assumptions for the transit corridor are:

– It will be a single track corridor with dual track at stations i.e. passing loops
– Level crossings will remain functional with traffic signals
– The existing Inner City Cycleway will remain functional and safe

GHD were engaged to undertake a condition assessment and remedial cost estimates for the corridor, noting that the infrastructure therein had not been used for passenger services since 1978, and that applicable regulations & standards have undergone significant development since that time, and generally are more stringent in their requirements for safety for transport users, the general public & surrounding community.

GHD undertook civil (hydraulic), geotechnical, environmental (contamination), structural and rail assessments and inspections of the current condition of extant corridor and associated infrastructure. This report outlines the findings and recommendations resulting from those assessments and inspections. A survey company was contracted to perform LiDAR and drone surveys & perform services locations of the full corridor to map for key feature extraction and allow the corridor alignment to be further assessed. GHD then undertook cost modelling of the outcomes, recommendations & findings of the assessments and field inspections to determine budgets (P50/P90) for the remediation and reinstatement of the corridor, on a mode-neutral basis.

The below summation by discipline captures the high-level findings and outcomes that are detailed within this report for input into engineering & design development for the future activation of the corridor for a contemporary Light Rail (LTR) or Bus Rapid Transit (BRT) transport system.

Civil summary findings:

A desktop assessment was undertaken of existing corridor drawings & prior reports, asset map and available contour data, then calculations were performed to determine hydraulic modelling performance. A physical inspection was then undertaken of the full corridor to perform measurements for each culvert and an inspection of existing culvert drain infrastructure/condition.

Culvert sizing (41 culverts found and inspected) was assessed against the Representative Concentration Pathway (RCP) 8.5 @ 1% Annual Exceeded Probability (AEP) event, noting this storm modelling is adopted from the requirements noted in the Track and Civil Infrastructure Design and Construction Standard (TR-INF-SD-027) by TasRail, and found:

– 12 existing culverts are of adequate size.
– 21 existing culverts are too small and require replacement to increase capacity to support anticipated drainage/rainfall events during next 50 years.

– 8 existing culverts were not-evaluated due to poor accessibility/mechanical system required to inspect/remove culvert lids/covers.

Geotechnical summary findings:

A geotechnical desktop study was undertaken to establish anticipated geological conditions for the corridor, followed by a full corridor physical inspection. Key findings include the following:

Landslide/rockfall susceptible areas were found to be at the Risdon Road Overpass area, the Domain Highway area and the Tasman Highway areas. These locations would require detailed investigations prior to any proposed works to widen or remediate the associated embankments in these areas.

Geotechnical hazards such as embankment instability & soft subgrade conditions were identified at 22 locations along the corridor and require further detailed investigation (invasive testing) to determine the extent, failure causes and mechanisms.

Geotechnical recommendations include the undertaking of intrusive investigations for identified soft substrate locations, a formal landslide risk assessment for each identified risk area, geological mapping of each occurrence of rock cutting face, and an embankment stability risk assessment.

Environmental summary findings:

A desktop review of available data including EPA records and adjacent property information (i.e. legacy land use activities such as petrol stations, process and manufacturing, chemical works) was undertaken and identified 14 areas of interest in relation to medium to high risk of contamination, predominantly in the northern industrial area of the corridor.

The report recommends site sampling and contamination testing to be undertaken for all medium and high risk locations, to inform for existing contamination levels and removal/reuse options along the extant rail alignment, i.e. disposal via appropriate receptor and/or identify for potential material re-use in corridor for cut/fill requirements (bus pavement) or as capping layer/ structural fill formation (light rail), in accordance with EPA guidelines.

Detailed investigations of legacy contamination of the corridor, land reclamation/acquisition requirements and environmental assessment & heritage approvals will be required to be undertaken prior to major remedial works being undertaken to restore the corridor, and to inform the early design stage.

Structural summary findings:

A desktop assessment of the Risdon Road Railway Bridge and New Town Rivulet Bridge was undertaken. Original drawings for each bridge structure were not available, however a past condition inspection report and structural rating were located for Risdon Road Rail Bridge, and a condition assessment report for New Town Rivulet Bridge.

A Level 2 condition inspection was undertaken for Risdon Road Railway Bridge and New Town Rivulet Bridge as part of the scope of works. The inspection found that both bridges were in reasonable condition given their age and exposure environment, which was consistent with previous reports. Observed defects as part of the inspection were logged and conceptual recommendations provided.

A structural review and estimation exercise found that replacing both Risdon Road Rail Bridge & New Town Rivulet Bridge would be more appropriate for the following reasons:

– Both bridges need to be design for the more onerous structural requirements of LRT and BRT to ensure that the bridges are future proofed for corridor transit mode changes.
– Both bridges require substantial widening to facilitate the minimum transport corridor width for either LRT or BRT modes, while maintaining the adjacent intercity cycleway.
– Both bridges require the installation of bridge barriers along the edge of the deck to prevent an errant BRT or derailed LRT falling onto Risdon Road or New Town Creek. This is much the same as the fundamental requirement to have bridge barriers on new bridges.

- Retrofitting bridge barriers to existing old bridges is inherently difficult to achieve, and likely some concession or significant strengthening works will be required to suitable design the system.
- Risdon Road Rail bridge is known to have been in service for >100 years (and likely New Town Rivulet will be similar). Strengthening and widening the existing bridge would still result in an asset age >100 years with likely ongoing maintenance issues as a result.

While Bellevue Parade Underpass (Brooker Highway Overpass), Tower Road Bridge and Tasman bridge were not part of the condition assessment scope directly, on review of the corridor width at these bridge locations it was determined that:

- Bellevue Parade Underpass (Brooker Highway Overpass) is likely to need replacing given the insufficient width of the corridor below, and a requirement for extensive pier protection for the bridge as a result of potential LRT impact (and to a lesser extent BRT). We note that this bridge has been identified for replacement in the next 2-6 years as part of the Domain Highway / Brooker Highway Upgrade Project to facilitate three (3) traffic lanes in each direction along the Brooker Highway at this location.
- Tower Road Bridge is likely to need replacing given the insufficient corridor width of the corridor below, and a requirement for extensive pier protection for the bridge as a result of potential LRT impact (and to a lesser extent BRT).
- Tasman Bridge will require pier protection measures, and while the corridor width is insufficient, replacement is not recommended given the asset size and importance. Further investigation will be required to better define the requirements at this location specific to the bridge.

Rail summary findings:

The rail team conducted an extensive desktop assessment of the corridor, including survey and drawing data, and developed initial traffic modelling and mode neutral cross sectional analysis to investigate corridor width, corner radii and passing loop/station location opportunities that would yield a nominal 10 minute headway. A full corridor physical inspection and report of the extant corridor rail infrastructure was then undertaken to identify further risk and issues associated with the existing corridor/infrastructure. The outcome was that the current corridor condition was found to be poor and therefore deemed currently unsuitable for either a modern Light Rail nor BRT service due to:

- The current rail gauge is incompatible for standard gauge vehicles, in addition to sleeper type and condition, and ballast condition being fouled / contaminated.
- Rail bridge replacement and traffic bridge protection works are required.
- Existing platforms are not DDA compliant and are on curves, and are therefore not supported by current standards.
- Traffic level crossings /pedestrian crossings are not compliant with current standards.
- Existing turnouts are not compatible with LTR /standard gauge, and are in poor condition.
- Extensive civil works are required for corridor widening, drainage and provisioning of CSR requirements, including associated land acquisition or reclamation requirements.
- Consideration should be given to upgrading level crossings (road and pedestrian) along the corridor to traffic signals and pedestrian operated signals
- Current rail alignment will require extensive rework to allow for compliant platforms (LTR or BRT), and for sufficient passing loops to yield acceptable headway. To provide passing opportunities – passing loops at stations and at locations between Albert Road and Derwent Road along with the Botanic Gardens are required in order to achieve an operating frequency (headway) of 10 minutes. (NOTE: a nominal 10 minute headway was modelled for this condition report, however we understand that a headway of 7.5 mins is a client aspiration to ensure best take-up/patronage of planned BRT/LRT services). Detailed assessment of timetabling and headway requirements will be required to resolve for future corridor alignment, requisite widening, passing loop & station numbers & locations, and road & pedestrian crossing locations, to inform the design phase.

– New fencing and lighting will be required to allow for safe use of the rail corridor in support of any proposed public transit operations (LTR or BRT).

Cost Estimate findings:

GHD undertook cost estimating and prepared a costed schedule for the corridor works indicated within this report, including drainage, structural protection, corridor widening, rail/ballast removal, provision of passing loops, and related works associated with corridor re-activation.

The total cost of corridor activation works was estimated to be $96 million. This cost includes a P50 level of contingency, but excludes any escalation. A cost estimate with a P90 level of contingency i.e. that is the Government is 90% confident that it can carry out the works for that price, is $161 million, excluding escalation. Further scoping works, including engineering investigations, technical studies and preliminary design are required to give the Government more accurate cost estimates with less allowance for contingencies.

The Prioritised work schedule indicates that an expenditure of $25 million will activate an approximate 2 km of the corridor between Peltro St & Birdwood Ave, Glenorchy. An alternative use of a budget of $25 million would be to remove the existing track and upgrade the drainage, replacing culverts for the entire corridor.

Next Steps

There is likely to be an 18 month period for the Government to undertake scoping work (engineering and approvals related studies) explained above to inform the early design stage and before any new construction on the corridor could commence. Initial suggested studies and engineering reports indicated by this condition assessment include:

– Rail alignment / timetabling study
– Traffic Impact Assessment
– Traffic Bridge impact protection assessment
– Heritage assessment
– Geotechnical detailed study
– Contamination survey, sampling and testing
– Culvert inspection for 8 x culverts not accessible during this report investigation

There are also legislative changes that are required to authorise work in the corridor that alters the existing track assets (i.e. rail, sleeper, ballast removal) and to ensure the corridor is protected for ongoing and future transit uses.

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1. Introduction

1.1 Purpose

The project objective is to confirm the condition of the existing Northern Suburbs Transit Corridor infrastructure to inform the Government of the nature and cost of upgrades required to operate a transit service, by providing a multi-disciplined condition report and the provision of a fully costed detailed works schedule achievable within a $25 million budget.

1.2 Scope and limitations

The study area for this commission is shown on Figure 1 and is limited to:

– "South Line" rail corridor from Peltro St, Glenorchy to McVilly Drive, Macquarie Point

Figure 1 Study area

1.3 Assumptions

– It will be a single track corridor with dual track at stations i.e. passing loops
– Level crossings will remain functional with traffic signals
– The existing Inner City Cycleway will remain functional and safe

2. Desktop assessments

2.1 Survey

UDM have been commissioned to provide a comprehensive survey and scanning services relating to the transport corridor, with a 360^0 drone survey of rail corridor, underground services location, LiDAR survey of rail corridor and feature extraction including fencing, bike path, rail, bridges, pedestrian crossings, and scanning and 2D drawings for New Town Rivulet bridge.

The output from the survey undertakings will inform the GHD technical team for inclusion in desktop analysis of the corridor, and will be compiled and provided to the client via large file transfer or physical media.

Detail of the survey undertakings include:

– LiDAR Survey
  - Longitudinal survey extents shall be from Peltro Street, Glenorchy to McVilly Drive, Hobart (approximately 9 km). Lateral survey limits to be a minimum of 15 m from the nearest running rail or from property boundary to property boundary (i.e. fence line to fence line), whichever is the greater extent.
  - The lateral limit should include the Intercity Cycleway.
  - The Lidar survey to be completed under the ICSM LiDAR Acquisition (Data to be Point Cloud RBG LAS).

– Feature Extraction
  - All locations of change of rail type and sleeper type shall be clearly identified with description for rail and sleeper type.
  - All Insulated Rail Joint / Insulated Block Joint locations.
  - For any turnouts encountered, Turnout Type, annotation, Toe position, last long bearers/timbers and crossing angles (if applicable).
  - Lineside features such as ballast profile, fences, track drainage, drainage, culverts including inverts and diameters, signs, walkways and pedestrian crossings, signalling equipment, signals, level crossing signage and anything else within the survey boundary shall be picked up and clearly annotated.
  - Survey to be accompanied by a supporting key / legend.

– Georeferenced Aerial Imagery
  - Orthorectified aerial imagery along the corridor (+/-50 mm)

– Underground Services
  - Track and trace Underground services, pits, pipes and cables; not limited to NBN, Telstra, LV & HV power, Water, Stormwater & Sewer. (GAS to be located by TasGas)

– Boundary Cadastre
  - Preliminary boundary model (+/-50 mm)

– 360 video of the rail corridor and bike path
  - Video captured with RPAS - Drone imagery along corridor.

2.2 Structural

2.2.1 Risdon Road Rail Bridge

2.2.1.1 General overview

The Risdon Road Rail Bridge spans Risdon Road at New Town. There are no known (original) construction drawings of the bridge.

The rail bridge cross-section consists of a single railway line on the northern side, and the Hobart Intercity Cycleway on the southern side. The original bridge cross-section consisted of two (2) railway lines; however, the southern railway line was decommissioned to facilitate the Hobart Intercity Cycleway.

The rail bridge spans over two (2) traffic lanes and two (2) pedestrian footpaths forming Risdon Road. Low voltage power lines pass under the bridge immediately adjacent to the western abutment.

The rail bridge consists of four (4) single span wrought iron girders braced together in pairs. A concrete deck slab is situated on the girders. It is unknown whether there is composite action between the girders and the deck slab (e.g. shear studs or similar welded to the top flange of the girders).

The substructure consists of 'massive' concrete retaining wall abutments and wingwalls. It is not known whether these are reinforced.

Both the northern and southern edges of the bridge have a pedestrian style guardrail.

Refer Figure 2 and Figure 3 for aerial image and elevation photograph of the bridge respectively.

Figure 2 ***Aerial photograph of Risdon Road Rail Bridge (Google maps 2021)***

Figure 3 Elevation photograph of Risdon Road Rail Bridge (Google maps 2021)

2.2.1.2 Drawings, past reports and assessments

GHD was able to source two documents for the Risdon Road Rail Bridge through the Stakeholder Engagement process, namely:

– The Transport Commission Tasmania Railway System Upgrading Mast Plan Wrought Iron Bridge Volume 1- Report, Maunsell & Partners Pty Ltd October 1976

– S4.65 Risdon Road Rail Over Level 2 Bridge Inspection, Department of State Growth

2.2.1.2.1 Wrought Iron Bridge Volume 1 – Report, Maunsell 1976

A condition assessment was undertaken by the consulting engineering firm Maunsell & Partners Pty Ltd (Maunsell) in 1976. As part of this review a set of detailed drawings capturing the geometry and (some) observable details of the bridge were prepared. Based on the prepared drawings the following major geometric and structural features were identified as follows:

– Four (4) 1867 mm deep stiffened riveted wrought iron girders braced in pairs at 1.91 m centres. Bracing positioned both in plan and laterally

– Simply supported girders seating on bearings

– Wrought iron girder span of 18.67 m (taken at centreline of bearing plate)

– Trough steel decking with 140 mm concrete overlay

– Assumed that each pair of rails are supported by a braced pair of wrought iron girders

– Bridge span between two ‘massive’ concrete abutments and wingwalls

– Bridge width of 8.1 m between barriers

Refer to Figure 4 for typical bridge cross section as extracted from the 1976 Maunsell Report.

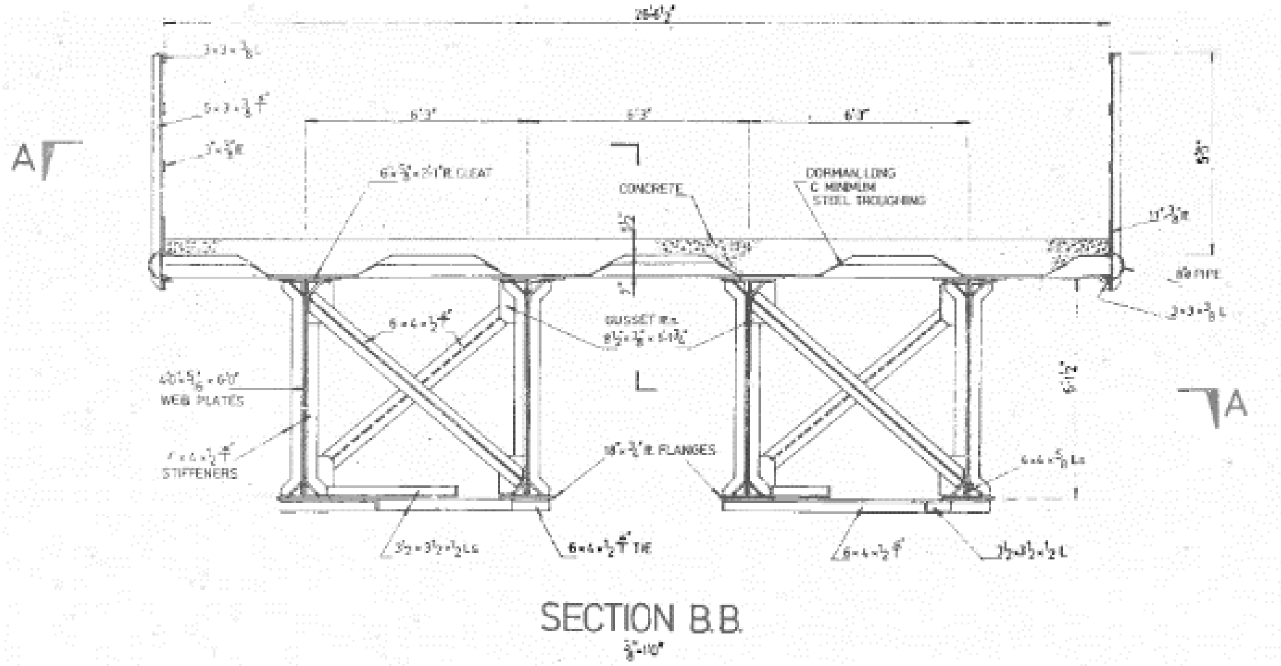


Figure 4 Typical bridge cross section

The onsite inspection and condition assessment noted the following with regards to the rail bridge superstructure:

– Rails were in good condition and the sleepers fair
– Ballast is reasonable, however heavy fines present
– Steel trough and deck in good condition apart from the edges of the wrought iron trough which were considerably rusted. If the concrete is unreinforced, then spalling may be expected
– Wrought iron girders and bracing in excellent condition
– Bearings appear to be functioning satisfactorily

The onsite inspection and condition assessment noted the following with regards to the rail bridge substructure:

– The masonry piers and abutments appeared to be in good condition except for some cracking around access manholes indicating slight abutment movement. This is not considered serious.
– The massiveness of the foundation tends to suggest no foundation problems are likely.

The Maunsell report also included a structural assessment of the bridge girders based on the geometry gathered from the site inspection. The structural assessment assumed:

– Composite action between girders and deck ignored since unknown connection
– Section properties based on net areas as measured on site
– Loading in accordance with Tasmanian Government Railways 'Coopers E40,' where impact, wind and other loads in accordance with AREA Chapter 15-7
– Allowable stresses have been calculated on the basis of *Criteria for Allowable Stresses in Wrought Iron Bridges*
– Abutments have not been analysed

The structural assessment results as extracted from the Maunsell report are summarised in Table 1, Table 2, Table 3 and Table 4.

Table 1 Maximum girder flange stress (tension and compression due to bending in girder)

Location	Actual Stress (MPa)	Allowable stress (MPa)	Actual/Allowable %
Midspan	168	138	122

Table 2 Maximum girder principal web stresses (due to combined bending and shear)

Location	Actual Stress (MPa)	Allowable stress ksi (MPa)	Actual/Allowable %
¼ point of simply support span	130	138	95

Table 3 Maximum rivet stresses (due to combined bending and shear in girder)

Location	Actual Stress (MPa)	Allowable stress (MPa)	Actual/Allowable %
Flange plate splice simply support span	124	138	90
Web plate splice at ¼ point of simply supported span	84	138	61
Web plate splice at centre of simply supported span	106	138	77

Table 4 Maximum bracing stresses

Location	Actual Stress (MPa)	Allowable stress (MPa)	Actual/Allowable %
3-1/2 x 3-1/2 x ½ L (tension)	57	75	75
3-1/2 x 3-1/2 x ½ L (compression)	28	65	44
3-1/2 x ½ PL (tension)	52	138	38
Maximum rivet stress	126	138	92

Note: Bracing stresses have been calculated using a timber deck only. The transverse stiffness of wrought iron trough and deck would reduce the stress considerably.

The conclusions of the condition and structural assessments indicated that:

- Flanges of wrought iron girders are overstressed at midspan for Coopers E40 loading
- Rail bridge rated to E28 loading with no restrictions on train speed; or E40 loading with 5 mph speed restriction
- Rating would considerably increase if composite action between deck and wrought iron girders be confirmed and allowed for in the assessment
- Abutments are in excellent condition, however, were not structurally assessed
- Foundations are considered adequate

Recommendations from the assessment included:

- The eventual replacement of the wrought iron trough along the edges of the bridge due to corrosion, however not critical at the time of the assessment
- Confirmation of any shear connectors between wrought iron girder and deck
- The presence of heavy fines within the ballast is not deemed critical at this stage

2.2.1.2.2 Rail Loading

In accordance with the Maunsell report the Risdon Road Rail Bridge was rated to a Cooper E28 load (equivalent to LRT of less than 15t axle load), or E40 (Branch Line Freight of less than 25t axle load) with a 5-mph speed restriction. Table 5 provides a further summary of rail loading vs track category.

The loading configurations for Cooper E28 and E40 are based on the standard Coopers E10 loading (i.e. 2.8 times the standard E10 and 4.0 times the standard E10 respectively). The standard E10 configuration is shown below for reference.

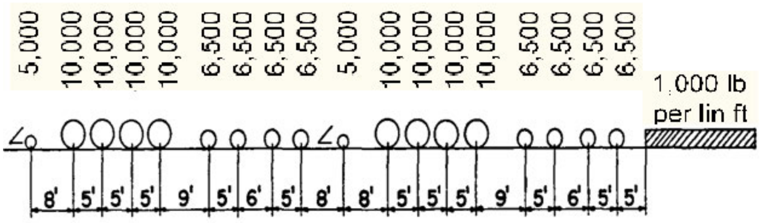


Figure 5 Standard Cooper E10 loading configuration

The following table provides a comparison between current loading requirements for LRT and Cooper Loading for reference.

Table 5 Rail load comparisons

Loading scenario	Design Standard Reference	Track category (as defined by AS5100)
300LA	Australian Standard AS5100	Heavy haul freight train (HHF) (axle load >25t)
150LA	Australian Standard AS5100	Light Rail (LR) (axle load <15t)
Cooper E80	American Railway Engineering and Maintenance-of-way Association (AREMA) Manual for Railway Engineering	Heavy haul freight train (HHF) (axle load >25t)
Cooper E40	American Railway Engineering and Maintenance-of-way Association (AREMA) Manual for Railway Engineering	Branch line freight (BLF) (axle load <25t)
Cooper E28	American Railway Engineering and Maintenance-of-way Association (AREMA) Manual for Railway Engineering	Light Rail (LR) (axle load <15t)
Cooper E10	American Railway Engineering and Maintenance-of-way Association (AREMA) Manual for Railway Engineering	Light Rail (LR) (axle load <15t)

2.2.1.2.3 Level 2 Bridge Inspection

A Level 2 Bridge Inspection was carried out in 2011 by TasRail. The findings of this assessment noted:

– Access to the bridge underside was limited by the height of structure, as such many components were not adequately inspected.
– The key defects noted by this inspection were corrosion to wrought iron members, and cracking in concrete.
– Recommendations for a level 3 inspection were made.

To GHD’s knowledge, no Level 3 Bridge Assessment has been carried out following this inspection.

2.2.2 New Town Rivulet Bridge

2.2.2.1 General overview

The New Town Rivulet Bridge spans the New Town Rivulet at New Town. There are no known (original) construction drawings of the bridge.

The rail bridge cross-section consists of a single railway line on the eastern side, and the Hobart Intercity Cycleway on the western side. The original bridge cross-section consisted of two (2) railway lines; however, the western railway line was decommissioned to facilitate the Hobart Intercity Cycleway.

A pedestrian footpath, under the bridge, provides access to the nearby New Town High School. The footpath is supported off the bridge girders and the southern abutment.

A chain wire mesh fence is provided on both sides of the Hobart Intercity Cycleway.

Refer Figure 6 and Figure 7 for aerial image and elevation photograph of the bridge respectively.

Figure 6 *Aerial photograph of New Town Rivulet Bridge (Google maps 2021)*

Figure 7 *Elevation photograph of New Town Rivulet Rail Bridge*

2.2.2.2 Drawings, past reports and assessments

There were generally no drawings, past reports or assessments identified for the New Town Rivulet Bridge. However, GHD was able to source a previous repair methodology to repair the sandstone walls, documented by Pitt & Sherry Pty Ltd and a previous Level 2 Condition Inspection report. The repairs are believed to have been conducted in 2018 and suggest that the sandstone abutment walls have experienced major deterioration over the years, with mortar loss being a key defect.

2.2.2.2.1 UDM Survey

As part of the desktop assessment, UDM were engaged to undertake a point cloud survey of the bridge to ascertain the geometric features of the bridge and further inform the condition assessment.

Based on the prepared drawings the following major geometric and structural features were identified as follows:

– Six (6) 690 mm deep steel I beam girders divided into two groups, with three girders at 1.25 m centres supporting the railway, and three at 1.25 m centres supporting the footpath. The girders are laterally restrained with 660 mm deep steel I beam cross girders
– Simply supported girders seating on bearings
– The girders span 6.5 m
– Bridge spanning between abutments consisting of sandstone on the western end, believed to be the original abutments, and concrete on the eastern end

2.2.2.2.2 Level 2 Inspection

A Level 2 Bridge Inspection was carried out in 2014 by TasRail. The findings of this assessment noted:

– Deteriorated sandstone abutments with the abutment at the northern bank exhibiting a major vertical crack between the abutment and the wingwall. Cracking was also found at the concrete section of the northern abutment
– Corrosion of bolts along the deck between middle beams
– Other minor defects such as vegetation growth and defects in the fencing

All defects were recommended to have been repaired within one month.

2.3 Hydraulic

Each culvert within the project area was subjected to hydraulic assessment in order to determine existing performance. The assessment included consideration of the following:

– Determination of contributing catchments using asset maps, available contour data, and aerial imagery
– Calculation of stormwater flow arriving at each culvert in accordance with methods specified in Australian Rainfall and Runoff 2019
– Hydraulic modelling of each culvert’s performance in the peak 1% Annual Event Probability (AEP) storm. This ARI is adopted from the Track and Civil Infrastructure Design and Construction Standard (TR-INF-SD-027) by TasRail
– Assessment of culvert performance 50 years from now using an increase in rainfall intensity interpolated from figures published by Australian Rainfall and Runoff, for both the Representative Concentration Pathway (RCP) climate change and prediction of rainfall 4.5 and 8.5 scenarios, used internationally to forecast for rainfall based on climate change predictions. These equate to 7% increase for the RCP 4.5 scenario, and 11.9% increase for the RCP 8.5 scenario, in the year 2070

2.3.1 Information adopted in the model

City of Hobart Council and Glenorchy City Council were able to provide digital information of the existing stormwater assets. This data, together with freely available data from the List Open Data repository (https://listdata.thelist.tas.gov.au/opendata/) and the site walkover, were used to assess the condition of the existing stormwater infrastructure along the Southern Line corridor:

– Topographic surface contours, 5 m interval
– Cadastre information
– Watercourse locations
– Existing track and road locations,
– Existing utilities (i.e. water, sewer, electrical, and communication assets, etc.) from DBYD and GIS information

This information provides a high-level definition of contributing catchments and related information such as catchment flow lengths and times.

2.3.2 Design criteria

The following criteria were adopted for the assessment of each culvert:

– Storm event – 1% Annual Event Probability (AEP) storm (approximate 100-year Average Recurrence Interval (ARI). This ARI is adopted from the Track and Civil Infrastructure Design and Construction Standard (TR-INF-SD-027) by TasRail
– Pipe slope determined from cover of 600 mm below the existing ground surface
– All culverts have been assumed as inlet controlled, and freely discharging
– All inlets were modelled as headwalls with no blockage factor applied

2.3.3 Modelling

Modelling was carried out using 12D Model software (version 14.0-C2j), to determine:

– Stormwater flow contributing to the existing culverts
– The suitability of existing culvert arrangements to convey the current 2% AEP flow
– The suitability of existing culvert arrangements to convey the 1% AEP flow with rainfall intensities increase to simulate the RCP 4.5 and RCP 8.5 climate change scenarios for 50 years from now
– Existing flow velocity effect on the longevity of site stormwater infrastructure

The results of this assessment depend upon the accuracy of information provided. This information is 'high level' and so the resulting calculations and recommendations should be regarded as indicative. More accurate information should be obtained to determine precise results where a more accurate result is desired.

2.3.4 Existing site description

2.3.4.1 Existing site

The catchment area of the first 3 km is largely a grassed field from the Queens Domain which consists of the Royal Tasmanian Botanical Gardens, Government House, Domain Athletic Centre and Cenotaph. The surface is generally pervious except for the road running parallel the track and the few buildings in the area. Surface runoff is generally directed into the existing culverts crossing under the rail corridor, before flowing toward the River Derwent in pipe systems or open channel.

The next 5 km is within the existing residential and commercial areas within New Town, Moonah and Glenorchy. The existing stormwater from the track is assumed to connect to the existing stormwater network that flows toward the River Derwent.

2.3.5 Hydrology

Identification and analysis of catchments contributing to, and within, the site was conducted using topographic surface contours from the List Open Data Repository, existing stormwater assets from City of Hobart and Glenorchy City Council, and field observation. Varying percentages of impervious and pervious catchment were assessed for catchments using aerial photography.

Hydrology for the project was determined using a Horton (ILSAX) loss model. ILSAX parameters were assumed for depression storage as follows:

– Impervious Area Storage Loss – 1 mm
– Pervious Area Storage Loss – 5 mm

Horton infiltration losses were adopted to simulate generally slowly infiltrating as follows:

– Soil type 3 slow infiltration (largely clay subsoils and rock), although areas of sand/gravel also exist within the area with greater infiltration potential. This will provide consistency of calculations and some contingency in the sizing of stormwater drainage infrastructure.

Rainfall intensities were adopted from ARR 2019 design rainfalls (obtained from the Bureau of Meteorology website and selected based upon times of concentration estimated for each contributing catchment.

A range of storm durations were assessed between 10 minutes and 12 hours. These durations are anticipated to cover the varying size and composition of contributing catchments.

A time of concentration for each pervious catchment was estimated for the high-level investigation using:

- Direct estimation for smaller catchments
- The Kinematic Wave Equation for longer flow paths within developed areas
- The Bransby Williams equation for larger undeveloped/developed catchments

2.3.6 Existing culverts along the study area

The location and size of the existing stormwater culverts were determined using the GIS information and confirmed during the site walkover. All culverts were arranged with an assumed cover of 1.2 m below the top of rail, as required by AS 4799 – 2000 'Installation of Underground Utility Services and Pipelines within Railway'.

No attempt was made to determine pipe sizes suitable for each storm situation considered as this may provide misleading advice due to the high-level culvert arrangement considered. Where specific culvert sizing is required, this must be undertaken with detailed information on a specific culvert basis.

A summary of existing culverts from this assessment is noted in Appendix A. A condition assessment of existing culverts was conducted and further discussed in Section 3.4 and Appendix B of this report. The chainage location of each culvert is included in the general arrangement drawings included in this report as Appendix A.

Table 6 Hydraulic Assessment Summary

Culvert location	Existing culvert Diameter	Existing culvert capacity for current 1% AEP storm	Existing culvert capacity for 2070 RCP 4.5 1% AEP storm	Existing culvert capacity for 2070 RCP 8.5 1% AEP storm	Proposed culvert pipe size for 2070 RCP 8.5 1% AEP storm	Culvert condition
Ch 279.06	DN 300 RCP	Insufficient	Insufficient	Insufficient	DN 750 RCP	Culvert outlet 100% blocked. Check pipe condition, clear outlet, replace missing headwall/wingwall.
Ch 494.45	DN 150 PVC	Insufficient	Insufficient	Insufficient	DN 450 RCP	Culvert barrel and outlet 75-100% blocked. Clear outlet of vegetation and dirt. Consider providing wingwalls to avoid dirt from batters moving towards outlet.
Ch 562.38	DN 300 RCP	Insufficient	Insufficient	Insufficient	2 x DN 750 RCP	Culvert outlet and barrel 25-75% blocked. Clear outlet of dirt and vegetation. Provide treatment for embankment scouring on inlet side.
Ch 726.83	DN 450 RCP	Insufficient	Insufficient	Insufficient	2 x DN 750 RCP	Culvert outlet 75% blocked.
Ch 866.01	DN 450 RCP	Insufficient	Insufficient	Insufficient	2 x DN 900 RCP	Unable to assess. Cannot lift pit lids to confirm pipe diameter or condition.
Ch 1017.63	DN 300 RCP	Insufficient	Insufficient	Insufficient	DN 450 RCP	Condition not determined due to difficult access. Culvert outlet not found.
Ch 1136.93	DN 300 RCP	Ok	Ok	Insufficient	DN 375 RCP	Culvert 75% blocked. Outlet end wall missing.
Ch 1163.18	DN 450 RCP	Ok	Ok	Ok	DN 450 RCP	Culvert 25% blocked. Culvert outlet not found.
Ch 1186.04	DN 450 RCP	Ok	Ok	Ok	DN 450 RCP	Good condition. Culvert outlet not found.
Ch 1293.92	DN 300 RCP	Ok	Ok	Ok	DN 300 RCP	Good condition. Culvert outlet not found.
Ch 1332.79	DN 450 RCP	Ok	Ok	Ok	DN 450 RCP	Culvert 100% blocked. Culvert outlet not found.
Ch 1373.91	DN 100 PVC	Ok	Ok	Ok	DN 100 PVC	Culvert 100% blocked. Culvert outlet not found.
Ch 1490.99	DN 375 RCP	Ok	Insufficient	Insufficient	2 x DN 675 RCP	Culvert 75% blocked. Culvert outlet not found.
Ch 1824.59	DN 750 RCP	Ok	Ok	Ok	DN 750 RCP	Culvert 25% blocked. Cracking and rust staining of pipe may indicate structural damage. End wall required at outlet.
Ch 1886.28	DN 750 RCP	Insufficient	Insufficient	Insufficient	4 X DN 900 RCP	Culvert 25% blocked. No headwall/wingwalls on culvert. Outlet pipe damage. Pipe outlet has cracks, chips and rusting, rock armour does not appear secure.

Culvert location	Existing culvert Diameter	Existing culvert capacity for current 1% AEP storm	Existing culvert capacity for 2070 RCP 4.5 1% AEP storm	Existing culvert capacity for 2070 RCP 8.5 1% AEP storm	Proposed culvert pipe size for 2070 RCP 8.5 1% AEP storm	Culvert condition
Ch 1971.45	DN 150 RCP	Insufficient	Insufficient	Insufficient	DN 750 RCP	Culvert 100% blocked. Clearing of debris will be required. Pipe support (headwall or wingwall) may be required, pipe may need to be replaced.
Ch 2129.51	DN 300 RCP	Insufficient	Insufficient	Insufficient	2 x DN 1050 RCP	Unable to assess. Machinery required to open manhole. Pipe condition underneath the track will need to be reassessed. clearing of debris/vegetation on outlet side will be required. pipe support (headwall or wingwall) may be required.
Ch 2242.87	DN 450 RCP	Ok	Ok	Ok	DN 450 RCP	Culvert 50% blocked. Pipe condition underneath the track will need to be reassessed. Clearing of dirt and debris on both ends will be required. RCP pipe appears to be connected to steel (?) pipe underneath the shared path. pipe may need to be replaced.
Ch 2343.74	DN 450 RCP	Insufficient	Insufficient	Insufficient	2 x DN 1050 RCP	Culvert 100% blocked. Pipe condition underneath the track will need to be reassessed. Clearing of rock and vegetation on outlet side is required. Clearing of rock dirt and dried leaved on inlet side is required. Pipe support (i.e. wingwall) may be required, inlet condition will need to be assessed.
Ch 2515.74	DN 450 RCP	Ok	Ok	Ok	DN 450 RCP	Culvert outlet 100% blocked. Outlet and pipe condition will need to be assessed. Cannot find outlet, clear debris and vegetation on either side.
Ch 2583.64	DN 225 RCP	Ok	Ok	Ok	DN 225 RCP	Culvert outlet 50% blocked. It appears that the existing pipe was extended with a different pipe type when the shared path was constructed. Clearing of debris/dirt/vegetation on either side is required. Pipe connection on inlet side will need to be replaced. Appears warped at connection.
Ch 2626.80	DN 450 RCP	Insufficient	Insufficient	Insufficient	DN 1050 RCP	Culvert outlet 50% blocked. Clear outlet of dirt and vegetation. it appears that the existing pipe was extended with a different pipe type when the shared path was constructed. Clearing of debris/dirt/vegetation on either side is required.

Culvert location	Existing culvert Diameter	Existing culvert capacity for current 1% AEP storm	Existing culvert capacity for 2070 RCP 4.5 1% AEP storm	Existing culvert capacity for 2070 RCP 8.5 1% AEP storm	Proposed culvert pipe size for 2070 RCP 8.5 1% AEP storm	Culvert condition
Ch 2683.38	DN 450 RCP	Ok	Ok	Ok	DN 450 RCP	Culvert outlet 50% blocked. It appears that the existing pipe was extended with a different pipe type when the shared path was constructed. Clearing of debris/dirt/vegetation on either side is required.
Ch 2891.70	DN 450 RCP	Insufficient	Insufficient	Insufficient	2 x DN 750 RCP	It appears that the existing pipe was extended with a different pipe type when the shared path was constructed. Connection of pipes should be assessed for joint displacement. Clearing of debris/dirt/vegetation on either side is required.
Ch 3062.22	DN 150 PVC	Insufficient	Insufficient	Insufficient	2 x DN 450 RCP	Culvert barrel and outlet 50% blocked. Culvert and outlet condition will need to be checked and cleared of obstructions/dirt. Clear inlet side. Check pipe blockage causing the stagnant water.
Ch 3249.52	DN 450 RCP	Insufficient	Insufficient	Insufficient	2 x DN 900 RCP	Side entry pit inlet will need to be cleared of dried leaves and debris. Outlet will need to be cleared of vegetation. No wingwall or headwall, thus dirt from sides encroaches the outlet path.
Ch 3623.98	DN 525 RCP and DN 900	Ok	Insufficient	Insufficient	3 x DN 1500 RCP	Unable to assess. Cannot lift pit lids to confirm pipe diameter or condition. Capacity assessment used CoH GIS data.
Ch 4153.86	DN 900 RCP	Ok	Ok	Insufficient	2 x DN 750 RCP	Unable to assess. Cannot lift pit lids to confirm pipe diameter or condition. Capacity assessment used CoH GIS data.
Ch 4193.51	DN 2400 RCP	Insufficient	Insufficient	Insufficient	2 x DN 2400 RCP	Unable to assess. Cannot lift pit lids to confirm pipe diameter or condition. Capacity assessment used CoH GIS data.
Ch 4348.93	DN 225 RCP	Insufficient	Insufficient	Insufficient	2 x DN 750 RCP	Culvert barrel 25% blocked. Culvert and outlet condition will need to be checked and cleared of obstructions/dirt. Outlet not found.
Ch 4993.00	New Town Rivulet Bridge				Unable to assess	New Town Rivulet Bridge. Not assessed for stormwater capacity.
Ch 5320.64	DN 450 RCP	Insufficient	Insufficient	Insufficient	4 x DN 1050 RCP	Culvert outlet 25% blocked. Difficult to open manhole cover. Inlet condition will need to be reassessed. A few

Culvert location	Existing culvert Diameter	Existing culvert capacity for current 1% AEP storm	Existing culvert capacity for 2070 RCP 4.5 1% AEP storm	Existing culvert capacity for 2070 RCP 8.5 1% AEP storm	Proposed culvert pipe size for 2070 RCP 8.5 1% AEP storm	Culvert condition
						vegetation in the way of the inlet, located on the left side of the shared path and track.
Ch 5937.06					Unable to assess	Unable to assess. Cannot lift pit lids to confirm pipe diameter or condition.
Ch 6404.54					Unable to assess	Unable to assess. Cannot lift pit lids to confirm pipe diameter or condition.
CH 6660.00 approx.					Unable to assess	Unable to assess. Cannot lift pit lids to confirm pipe diameter or condition.
Ch 6677.36	DN 1050 RCP	Ok	Ok	Ok	DN 1050 RCP	Vegetation around the grated pit but appears to be in reasonable condition aside from the bent grates in the cover. Grated pit cover can easily be opened.
Ch 6839.34					Unable to assess	Unable to assess. Cannot lift pit lids to confirm pipe diameter or condition.
Ch 7036.96					Unable to assess	Unable to assess. Cannot lift pit lids to confirm pipe diameter or condition.
Ch 7420.00	DN 225 RCP	Ok	Ok	Ok	DN 225 RCP	Culvert and inlet condition will need to be checked and cleared of obstructions/dirt. Clear inlet side.
Ch 7659.30					Unable to assess	Unable to assess. Cannot lift pit lids to confirm pipe diameter or condition.
Ch 7727.52 and Ch 7721.68					Unable to assess	Unable to assess. Cannot lift pit lids to confirm pipe diameter or condition.

2.3.7 Summary of culvert investigation

Each culvert within the project area was subjected to hydraulic assessment in order to determine existing performance.

The following design criteria were adopted, as required by the project brief:

– Hydraulic modelling of each culvert's performance in the peak 1% Annual Event Probability (AEP) storm. This storm is adopted from the requirements noted in the Track and Civil Infrastructure Design and Construction Standard (TR-INF-SD-027) by TasRail.
– The results of this assessment depend upon the accuracy of information provided such as 5 m interval LiDAR contours. This information is 'high level' and so the resulting calculations and recommendations should be regarded as indicative. More accurate information should be obtained to determine precise results where a more accurate result is desired.
– Assessment of culvert performance with an allowance for climate change, 50 years from now, was estimated using an increase in rainfall intensity interpolated from figures published by Australian Rainfall and Runoff, for both the RCP 4.5 and 8.5 scenarios. These equate to 7% increase for the RCP 4.5 scenario, and 11.9% increase for the RCP 8.5 scenario, in the year 2070.

  In the characterisation of climate change projections, the RCP 8.5 scenario is accepted to represent "worst-case" scenario while the RCP 4.5 scenario presents a case where some action is taken to address human factors contributing to climate change.
– Indicative culvert sizes were proposed to cater for the 2070 RCP 8.5 1% AEP storm.
– Of the forty-one culverts assessed:
  - twenty-one culverts are believed to be too small to cater for the nominated storm event
  - Twelve were of adequate size
  - Eight were not assessed due to difficulty in determining existing culvert sizes as pits could not be opened, dangerous outlet locations.
– The proposed size of drainage culverts shall be considered indicative only, for the purposes of construction cost estimation.
– The investigation outlined in this section is intended to provide an indication of current and future viability of each culvert. Additional information will need to be obtained, such as more accurate level data/survey, to confirm the suitability of the infrastructure in the design stage.

2.4 Geotechnical

A geotechnical desktop study was undertaken to ascertain the anticipated geological conditions and potential geohazards along the transit corridor. The study entailed a review of published data available in the public domain (e.g. Mineral Resources Tasmania geological maps), and other relevant information obtained from previous investigation reports, as provided by DSG.

2.4.1 Regional surface geology

A review of the Mineral Resources Tasmania's 1:25,000 scale map indicates that the surface geology along the transit corridor is variable. In general, the southern section of the corridor is generally underlain by Jurassic Dolerite and transitions into various Cretaceous to Quaternary age alluvial sediments and deposits.

A summary of the geological units encountered is presented in Table 7, in order of youngest to oldest.

Table 7 Surface Geology of transit corridor

Geological Symbol	Description
Qhmm	Quaternary man-made deposits
Qham	Quaternary age alluvium and marsh deposits of modern flood plains
Qpad	Quaternary alluvium of river terraces, dolerite derived

Geological Symbol	Description
TQh	Tertiary undifferentiated alluvial deposits, possible beach gravel and poorly cemented conglomerate
TQd	Cretaceous to Quaternary swamp deposits of sand, clayey sand, silt, and minor gravel
Tsi	Cretaceous to Quaternary siltstone, sandstone, and claystone
Jd	Jurassic dolerite
Rqph	Permian to Triassic quartzose to feldspathic sandstone

An extract of the 1:25,000 Geology of Hobart mapsheet is presented in Figure 8.

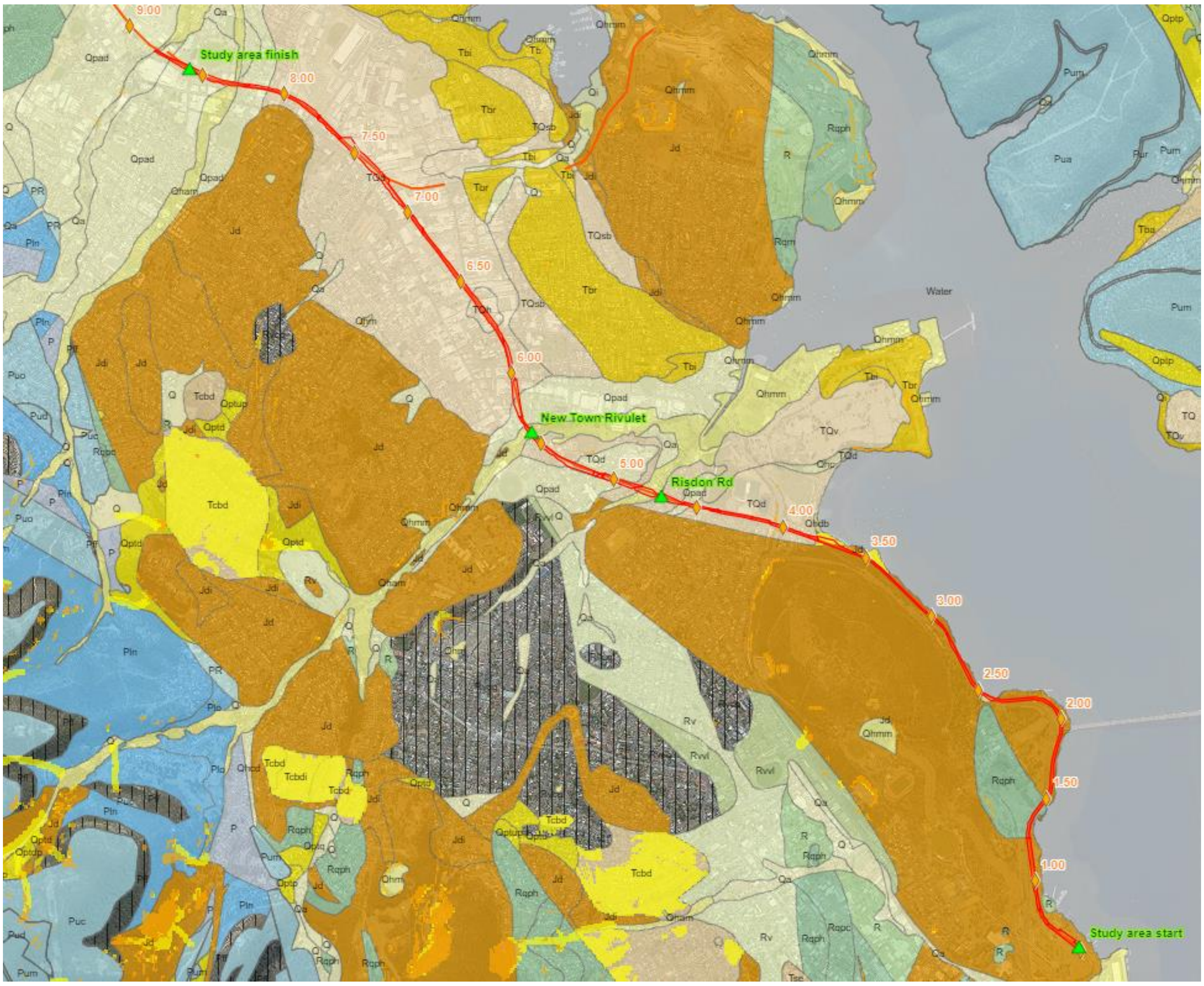


Figure 8 *1:25,000 Geology of Hobart mapsheet extract*

2.4.2 Acid Sulfate Soils

Acid Sulfate Soils (ASS) is the common name given to acidic or potentially acidic soils containing iron sulfides (predominately pyrite) and/or sulfates (predominantly jarosite). ASS include Actual Acid Sulfate Soils (AASS) and Potential Acid Sulfate Soils (PASS). ASS can occur in coastal and inland settings.

PASS typically form when there is a combination of waterlogged and/or oxygen-free conditions, a source of sulfate from seawater or saline groundwater, the presence of oxygen-consuming organic matter, and metals such as iron.

These soils generally occur in Quaternary aged (1.8 million years ago (Ma) – present) marine or estuarine sediments. They are predominately confined to coastal lowlands with elevations below 10 metres Australian Height Datum (mAHD). The ASS of most concern are those generally confined to Holocene aged (<10,000 years) soil material.

Under natural conditions, PASS is located below the water table, as sulfidic material above the long-term water table is likely to have previously been oxidised and had the acid leached from the soil. Left undisturbed, PASS do not generally pose a risk to the environment but when exposed to oxygen, the metal sulfides have the potential to oxidise and form sulfuric acid, becoming AASS. Under acidic conditions, metals such as aluminium and iron, as well as trace heavy metals (e.g. arsenic), become soluble and are mobilised by infiltrating water. Dissolved oxygen concentrations in surface water are likely to be low in affected areas.

A review of the coastal Acid Sulfate Soils (ASS) database available through the Department of Primary Industries, Water, and Environment LISTmap services, indicates that the project site has areas of Low probability (6 to 70%) of being susceptible to ASS. These areas are generally contained to coastal zones (Macquarie wharf) and areas in and around creeks and rivulets (Figure 9 and Figure 10).

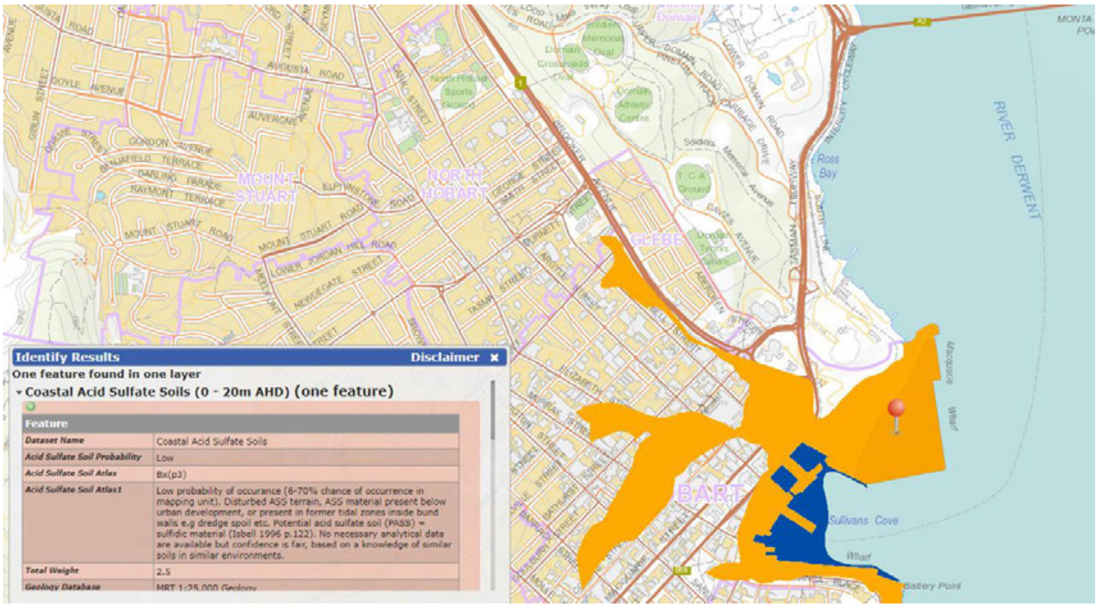


Figure 9 ***Areas susceptible to acid sulfate soils (low probability)***

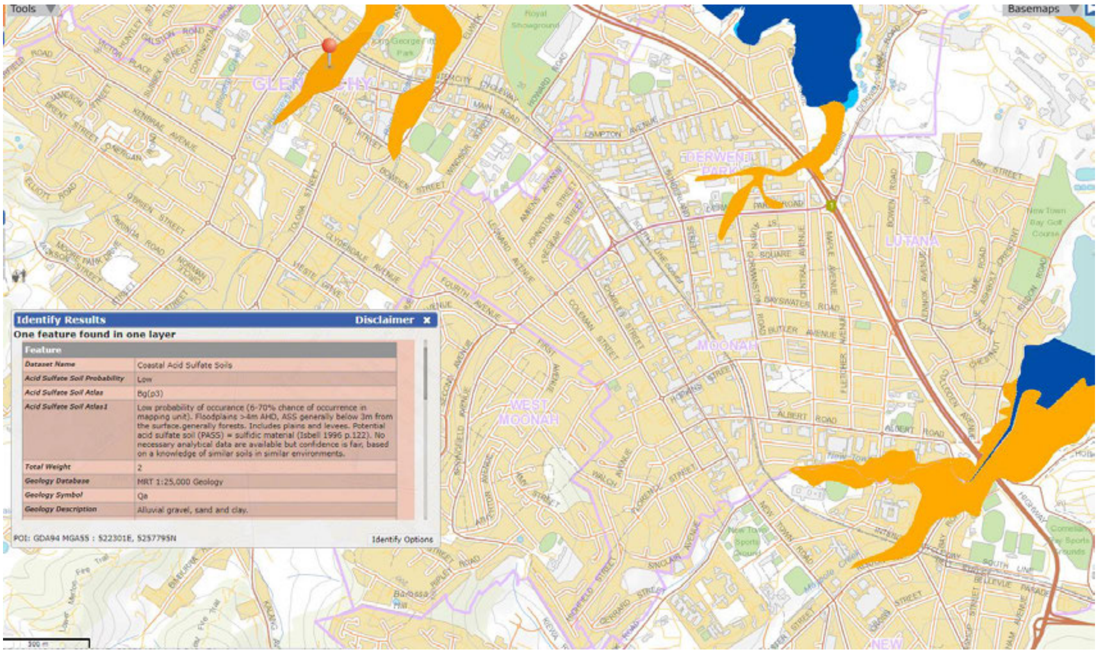


Figure 10 ***Areas susceptible to acid sulfate soils (low probability)***

2.4.3 Landslide susceptibility

A review of the MRT landslide susceptibility mapping and hazard bands, available through the Department of Primary Industries, Water, and Environment LISTmap services indicates that the project site has several small landslide susceptible areas that are relevant to this project (Figure 11, Figure 12, Figure 13).

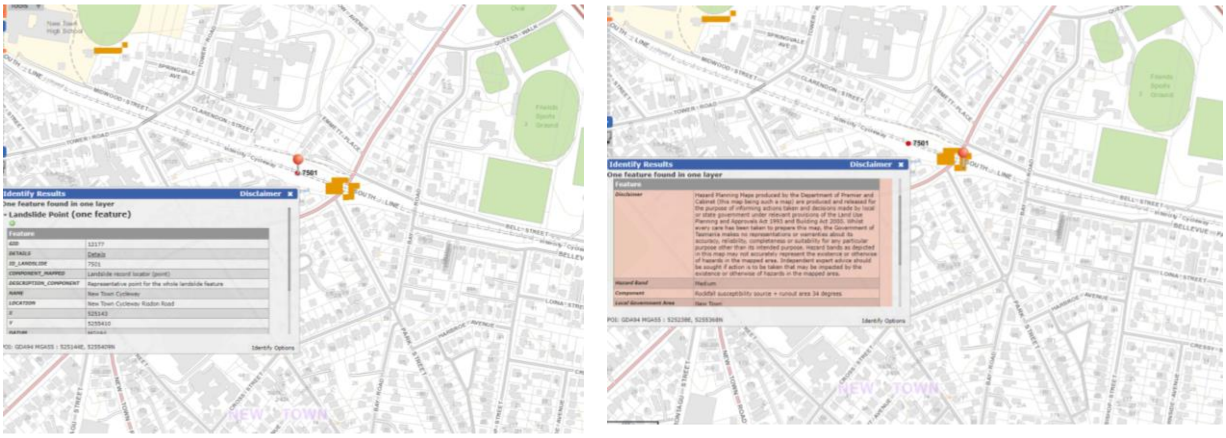


Figure 11 ***Areas susceptible to landslide/rockfall (located at Risdon Road overpass)***

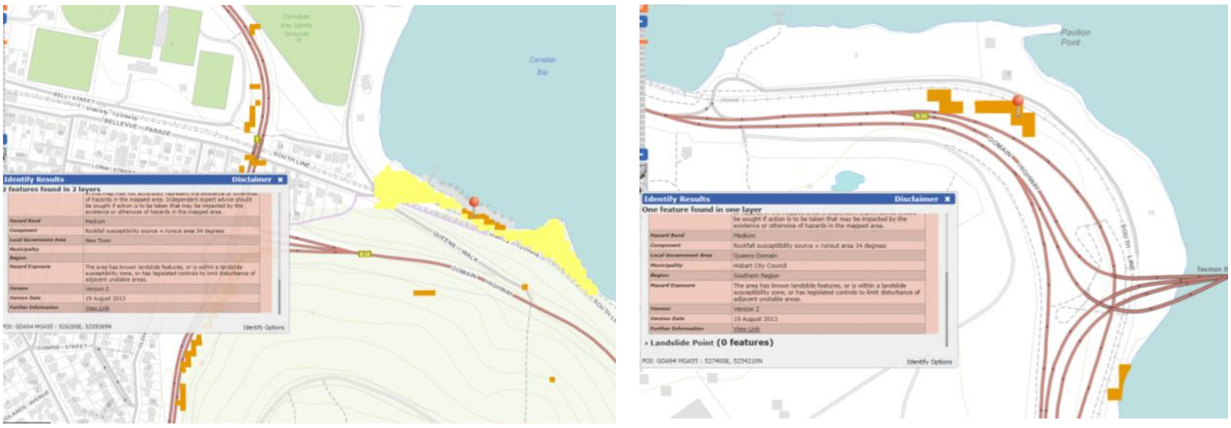


Figure 12 ***Areas susceptible to landslide/rockfall (Domain Highway area)***

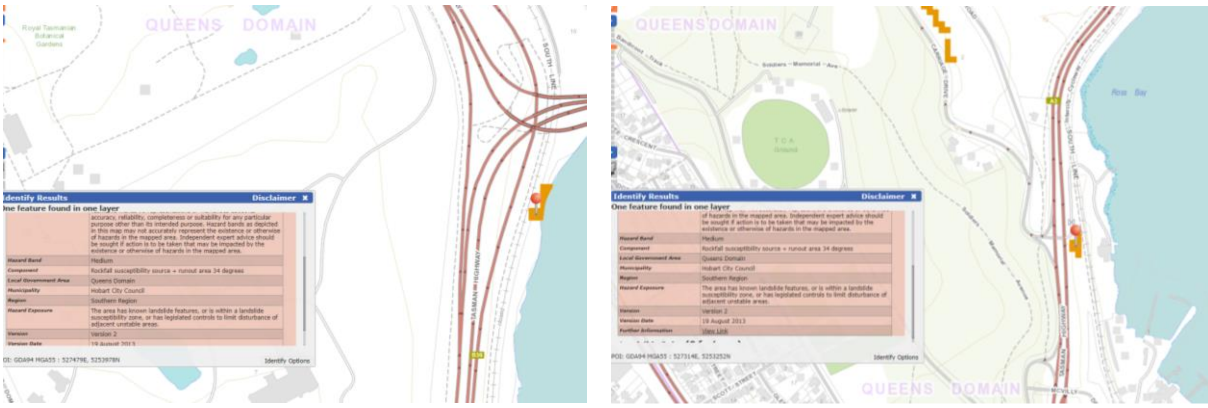


Figure 13 ***Areas susceptible to landslide/rockfall (Tasman Highway area)***

2.4.4 Groundwater

A search on the Tasmanian Government groundwater information portal revealed no groundwater monitoring bore information exists in the vicinity of the transit corridor.

2.4.5 Previous investigations

2.4.5.1 Intercity Cycleway – Geotechnical Assessment, pitt&sherry, 2018

pitt&sherry were engaged by City of Hobart in 2018 to undertake a geotechnical investigation and risk assessment of a section of the Intercity Cycleway between Risdon Road and Tower Road that was showing ongoing signs of distress and cracking. A summary of the outcomes of the investigation and risk assessment is provided below.

– The site walkover indicated that there are many slope instability features on the southern embankment slope.
– A headscarp of a small, more recent slip on the slope gave a good exposure of the material present in the upper layers of the embankment and generally comprised silty CLAY; high plasticity, black to dark grey, with sand, gravel and cobbles of a wide variety of materials, including basalt, dolerite, siltstone, quartzite and ash.
– The southern side of embankment is typically at 36° to 37°, while inspection of the northern side of the embankment from the footpath at the base indicates it is generally 30°-32°. There were no signs of instability noted on the northern side of the embankment, though this was not closely inspected due to proximity to the rail line.
– Inspection of the cycleway trafficable area resulted in several signs of distress being identified, including:
  - The southern fence is rotated outwards
  - The northern fence shows a distinct vertical deflection
  - Rotation and tilting were noted in two light poles
  - Tilting of the concrete slabs on the surface of the cycle way
  - Cracking of the concrete slabs on the cycle way and reinstatement works using asphalt
– 30 Farnell probe tests were undertaken on the southern embankment, indicating that the in-situ CBR of the embankment is between 0.5% and 1.5%.
– The primary cause of the distress to the cycleway surface appears to be consolidation of the poor materials in the more recent fill, and the strong differential settlement across the ends of the bridge is leading to the tilting of concrete slabs and some of the sharpest height differentials on the section of cycleway under investigation.

2.5 Contamination

2.5.1 Introduction

A preliminary assessment of potential contamination along the Corridor was undertaken to identify potential contamination or legacy contamination as a result of potentially contaminating activities (PCA) being undertaken within the Corridor or, on lots adjacent to the Corridor. The results of the study are intended to support the condition assessment by identifying areas where potential contamination may be present along the corridor.

A full copy of the preliminary contamination assessment is presented in Appendix C, and the following presents a summary of the findings.

2.5.2 Objectives and scope

The objective of the assessment was to identify locations that may require further assessment of potential contamination to ensure that contamination is identified and managed appropriately. This was done by identification of lots on land that may have been subject to potentially contaminating activities using GIS-based analyses, information from local and state government databases, and land use history data to identify PCA that have been undertaken on or adjacent the Corridor.

Following identification of lots with potential contamination issues, relative risk rankings have been applied to identify which lot locations which should be subject to more intensive assessment.

The risk rankings were based on historic land-use information and comprise:

– Low Risk - sites that have been regulated and managed effectively, or present historical activities that would not lead to gross contamination within adjacent lots.
– Medium or High Risk (Requires Investigation) – sites that present a land use history of PCA including fuel storage, chemical uses, and/or industrial activities with potential contaminates of concern.

Sites identified as Medium or High Risk are considered to require further investigation to assess potential materials handling considerations including offsite disposal and risks to human health and the environment.

2.5.3 Findings

Ballast along the corridor should be sampled and analysed for key analytes to assess material handling and disposal requirements. This should be undertaken on a limited basis to inform decisions regarding disturbance of soils and ballast along the corridor, and on a detailed basis following confirmation of areas that will be disturbed. Appropriate management of material disturbance, disposal or material reuse should be undertaken wherever the presence of materials containing asbestos, heavy metals and hydrocarbons are detected.

Table 8 below presents a summary of lots identified to present a Medium or High Risk of contamination extending onto the rail corridor. A full copy of this table including Low Risk sites and further cadastral and ownership information is presented in the preliminary contamination report in Appendix C.

Table 8 Medium and High Risk Sites requiring further assessment

Site ID (in this report)	Address	Potentially Contaminating Activity History	Risk ranking
PC#1	1 McVilly Drive, Queens Domain, TAS 7000	Marine Vessel Slipyard history of marine engineering activities – evidence of hydrocarbon loss in historic imagery (1996) staining ground surfaces around the jetty system constructed in 1996 and the slipways. A refuelling jetty was identified east of the slipways extending approximately 75 m into the river and a well-bunded above-ground fuel storage tank (AST) is located at its entrance (on reclaimed land). Adjacent the AST is an area with a shipping container and small offices which is currently subleased to a marine painter (formerly the water police headquarters). A second jetty of approximately 80 m length was identified which is assumed to be generally utilised for the servicing of vessels. A chemical and oil store was identified at either end of the workshops that are to the south of the AST (and located on the road leading to the waterfront). South-east of these workshops is another laydown area and a third slip. The southern portion of the Domain Slip lot hosts a car park and a lockable laydown area.	Medium – considered unlikely that contamination extends onto Transit Corridor. Requires assessment of likelihood that potential contamination extends onto Corridor.

Site ID (in this report)	Address	Potentially Contaminating Activity History	Risk ranking
PC#3	1 Bell Street, New Town, TAS 7008	Motor Car Dealers - Engineering & Garages activities between 1970 and 1988 – Possible legacy hydrocarbon contamination (operation under B.R. Bean; H.C. Sleigh/Golden Fleece). Site also operated as a Food distributor and Wholesaler. (W.P.L Food Distributors; Wholesalers Pty Ltd). Structure utilised for activities of these types was demolished in 1997 and replaced with a concrete surface operating as a car park to support the rezoning and use of the parcel to recreational uses. Asphalt car parking was adjoined subsequently.	Medium – requires assessment of likelihood that potential contamination extends onto Corridor.
PC#4	367 Main Road, Glenorchy, TAS 7010	Possible abandoned service station or old bulk fuel storage systems situated at 359 MAIN RD GLENORCHY TAS 7010. Imagery and land use analyses indicate the site featured bulk fuel storage (USTs) for a period. No register of installation or removal date is specified.	Medium – requires assessment of likelihood that potential contamination extends onto Corridor.
PC#5	227 Main Road, Derwent Park, TAS 7009	Possible abandoned service station or old bulk fuel storage systems @ 231 MAIN RD DERWENT PARK TAS 7009. History of underground bulk fuel storage systems largely unknown.	Medium - requires assessment of likelihood that potential contamination extends onto Corridor.
PC#6	8 Birdwood Avenue, Moonah, TAS 7009	EPA Regulated premises directly adjacent rail corridor – Storage and treatment of controlled wastes operated by Spectran Group Pty Ltd. Possible abandoned service station or old bulk fuel storage systems @ 183 Main Road, Moonah, TAS 7000.	High - requires further investigation to assess whether potential contamination extends onto Corridor.
PC#7	Corner Main & Derwent Park Road, Derwent Park, TAS 7009	Sanitarium Health Food Co – food production facilities and manufacturing. Possible legacy sanitary operation contamination.	Medium - requires assessment of likelihood that potential contamination extends onto Corridor.
PC#8	18 Sunderland Street, Moonah, TAS 7009	Possible abandoned service station or old bulk fuel storage systems @ 131 MAIN RD MOONAH TAS 7009 – possible hydrocarbons. Site and adjacent sites function as commercial services and manufacturing – ceramic supplies, auto bodyworks panel manufacturing, auto servicing, and stone stockpiling uses occur within close proximity of the site and the rail corridor.	Medium – requires assessment of likelihood that potential contamination extends onto Corridor.
PC#9	313A Main Road, Glenorchy, TAS 7010 & 315-319 Main Road, Glenorchy, TAS 7010	Possible abandoned service station or old bulk fuel storage systems @ 323-325 MAIN RD GLENORCHY TAS 7010 (Parcel 7332948) – Possible hydrocarbon contamination.	High – requires further investigation to assess whether potential contamination extends onto Corridor.

Site ID (in this report)	Address	Potentially Contaminating Activity History	Risk ranking
PC#10	43 Albert Road, Moonah, TAS, 7009	Identified ERLUR site under Dangerous Goods register ID 2390 – no specific contamination information, land titles, or activity information was available.	Medium - requires assessment of likelihood that contamination is present and if so, extends onto Corridor.
PC#11	24 – 26 Station Street, Moonah, TAS 7009	Possible abandoned service station or old bulk fuel storage systems @ 52 ALBERT RD MOONAH TAS 7009 (Parcel 5403773). Possible hydrocarbon contamination.	Medium - requires assessment of likelihood that potential contamination extends onto Corridor.
PC#13	11-21 Derwent Park Road, Derwent Park, 7009	Storage and supply of gas, chemicals and industrial equipment – Gas tanks likely; chemical contamination possible.	Medium - requires assessment of likelihood that potential contamination extends onto Corridor.
PC#14	10-12 Derwent Park Road, Derwent Park, TAS 7009	Multiple ERLUR records available for the site - Kemp & Denning - LPG; Underground Storage Tanks (1974-1987); Sims Metal Ltd - 1x1000 gall U/G tank installed (1974).	Medium – requires assessment of likelihood that potential contamination extends onto Corridor.
PC#15	82 Hopkins St, Moonah, TAS 7009	Barrengers (glass manufacturing) – records of LPG tank installation.	Medium - requires assessment of likelihood that potential contamination extends onto Corridor.
PC#16	227-235 Main Road, Derwent Park, TAS 7009	Possible abandoned service station or old bulk fuel storage systems @ 231 MAIN RD DERWENT PARK TAS 7009 (Parcel ID 5437260) – possible hydrocarbon contamination.	Medium – requires assessment of likelihood that potential contamination extends onto Corridor.

2.5.4 Conclusions and recommendations

The assessment identified 16 lots with historical potentially contaminating uses in vicinity to the Northern Suburbs Transit Corridor. Fourteen of the lots were identified as having a Medium or High risk of potential contamination and requiring further investigation to assess if potential contamination is likely to or has extended into the Corridor.

Two of the lots investigated as part of this study were deemed to have a low contamination risk rating. These sites are not considered to trigger the requirement to undertake a detailed contamination risk assessment as part of Stage 2 works.

Sites requiring further assessment

A number of lots investigated have an elevated risk of contamination being present. This study recommends that all Medium and High Risk sites identified in Table 1 (Section 2.5.3 be further assessed (i.e. as Stage 2 investigations).

It is recommended that further (e.g. Stage 2) investigations be conducted for all sites identified as requiring further investigation i.e. Medium or High Risk sites. The Stage 2 investigations will generally include review of site layout plans, as constructed diagrams, licences and other information that may show the locations where PCAs were carried out, as well as indicate time frames for these activities and any previous environmental assessment reports or decommissioning reports that may be available for review. A site inspection and, where possible interviews, would also be undertaken to confirm the database information and identify potentially contaminating land-use activities. It is proposed that limited sampling be undertaken at key locations during this process to obtain preliminary information on soil quality (particularly for High Risk sites).

Sites identified as requiring further assessment benefit from completion of the further work to identify and understand the potential contamination at a site-specific level, including potential point-sources and broadscale contamination, potential sensitive receptors, and transport and exposure pathways.

In such cases, assessment of contaminated sites should be undertaken in accordance with the National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013) (the ASC NEPM), and the Environmental Management and Pollution Control Act 1994 (EMPCA).

3. Condition assessments

3.1 Rail

A site inspection involving a walk-through of the corridor was undertaken on 7 July 2021. The inspection covered approximately 8 km of track focusing on the existing condition of turnouts, rails, joints, fastenings, sleepers, ballast, embankments and track drainage.

A technical memorandum was prepared on 13 July 2021 summarising the rail corridor inspection. The following is a summary of the high-level assessment.

3.1.1 Gauge

– Existing track is narrow gauge (3 ft 6 in / 1067 mm).
– Many light rail systems and vehicles around the world use standard gauge (1435 mm) including the two largest Light Rail Vehicle systems - Melbourne and Vienna. As such, most manufacturers around the world are set up for and are producing trams with standard width bodies and standard gauge track bogies.
– Renewing / reconditioning / upgrading the existing track through the northern suburbs transit corridor while maintaining the narrow track gauge will result in paying large premiums on capital costs and importantly, all operating and maintenance costs for the system and light rail vehicles. It could also impact on the stability of the light rail vehicle.
– It is strongly recommended the track gauge is changed to standard gauge for the running of light rail vehicles.

3.1.2 Rail

– Existing rail is either 63 lb/yd (31 kg/m) or 82 lb/yd (41 kg/m)
– Existing rail head would require complete reprofiling if rail is reused
– Heavy rail profile does not match requirements of rail profile for light rail
– Rail head is visibly worn excessively in multiple locations
– No fish plate joints were noted – it is assumed majority of the existing track is continuously welded rail

3.1.3 Track / Corridor

– Corridor was originally built to allow for two heavy rail freight tracks. Only one abandoned track remains, second track was removed and replaced with cycling path.
– Existing houses along the northern section of the corridor back up hard against the corridor and at some points, properties appear to use the corridor as part of their backyard. Vehicles are also parked within the corridor. Access to corridor would need to be restricted through additional security measures and infrastructure, such as fencing.
– Existing corridor is very tight through certain sections due to existing infrastructure (road overpasses, pedestrian overpasses, pedestrian underpasses, culverts, existing embankments) and the adjacent bike path. Widening the track to standard gauge would require some degree of infrastructure works to existing structures and earthworks, even more so if duplicated track is required.
– Considering the future transit will be majority single track with passing loops, the length of track between crossing points within the corridor will impact on the achievable timetables and scheduling of light rail vehicles, and could massively impact the number of trams able to run along the track at any given time.

3.1.4 Sleepers / Bearers

– Existing track has intermittent steel and timber sleepers.
– Majority of timber sleepers are not in good condition (visible splits or rotting) and some broken steel sleepers were noted. Ballast / organic fill (vegetation) is over the top of sleepers at certain sections of the corridor, and

this would likely be rusting steel sleepers if they are underneath. As such, the majority of sleepers will need to be replaced to allow for a new light rail system to be implemented.

– Specific impacts of changing track to standard gauge:
  - Sleepers for narrow track would be too short for standard gauge requirements
  - Steel sleepers would all need to be replaced
  - Most timber sleepers / bearers are not in good enough condition to be used for standard gauge – would need to be replaced
  - Modern sleepers typically are made of concrete

3.1.5 Turnouts

– All existing turnouts would need to be replaced for the following reasons:
  - Allow for light rail vehicles – wheel profile of heavy rail differs to light rail
  - Poor condition of turnout rail (rail head worn away, blades locked into position, toe of blade low against stock rail)
  - Allow for standard gauge track – current turnout geometry based off narrow gauge

3.1.6 Ballast / Track formation

– No geotechnical investigation has been undertaken to know exact condition of bottom ballast or track formation. However, organic growth is visible through the top of ballast along major sections of corridor, which indicates bottom ballast and formation is fouled (contains mud/dirt) allowing vegetation to grow.

– New ballast would be required for entire corridor.

3.1.7 Drainage

– Cess drains are not visible along most of the corridor length. Where they are visible, they are often only on one side of the track and are fouled with vegetation and often too low to appropriately drain track. At certain sections no drainage is apparent.

3.1.8 Embankment

– At multiple sections of the corridor, the track is located on top of high and very steep embankments. Minimum distance from nearest rail to embankment edge is noted to be 1.8 m and the maximum distance recorded is 3.0 m. These tight distances to the existing embankments limit the duplication of the track and would require major earthworks to widen the transit corridor.

– The embankment appears to be failing in at least one location, where the track and bike path fencing sag noticeably and the embankment bulges near the toe. This embankment does not appear stable enough to support an active light rail system and would need a complete geotechnical assessment and earthworks to improve stability, to allow light rail vehicles to run along this section of the corridor.

3.1.9 Level Crossings (Pedestrian and Road)

– Majority of pedestrian crossings do not appear compliant with DDA requirements and will need to be upgraded to achieve modern accessibility and safety standards.

– Flangeways within road crossings are heavily fouled with vegetation.

– Existing level crossings will need to be renewed:
  - Sleepers appear to be bulging / rotting beneath asphalt and will need to be replaced
  - Changing from narrow to standard gauge will require re-laying the rail
  - Crossing protection will need to be upgraded from passive to traffic signal control (similar to tram crossings in Melbourne and Queensland)

3.1.10 Platforms

- Existing platforms do not have compliant vertical or horizontal offsets to nearest rail and certain platforms are curved, which is non-compliant with modern design standards (either platform or rail will need to be reconstructed).
- Platforms do not appear to be compliant with DDA requirements and will need to be upgraded to provide full accessibility as per Australian Standards.
- Embedded rail (not ballasted track) to be laid along each platform to minimise vehicle bounce.

3.1.11 Corridor past end of track

- Existing rail does not extend all the way into the city of Hobart. New track will be required to connect the existing transit corridor into the city through the existing Port of Hobart hardstand area, and likely up Evans St to continue inwards to a terminal stop (location to be determined).

3.2 Geotechnical

3.2.1 General

An assessment of existing geotechnical hazards along the transit corridor was conducted between 26 and 28 July 2021. The assessment was conducted along approximately 8 km of the Southern Line corridor between Macquarie Point and Northgate Shopping Centre. The assessment incorporated the information obtained during the desktop study process and included additional features such as culverts, rail platforms and level crossings. Hazard attributes and observations were recorded directly into Collector using a tablet computer on site. Each hazard location was then photographed against each recorded observation.

The site inspection focused on features including:

- Embankment slope and height: Dimensions and conditions of the existing rail embankment, particularly areas of steep embankment and height and condition, including evidence of slope instability
- Rock cuttings: Condition of existing rock cuttings including geology, weathering, rock strength and fracturing
- Slope stability: Evidence of slope instability in cuttings adjacent to the existing rail formation within the transit corridor
- Evidence of instability or settlement in the railway subgrade such as evidence of thicker ballast layers and soft subgrade zones
- Corridor width: Noting areas where duplication of the transit corridor may be difficult or areas where the corridor would accommodate duplication
- Retaining structures: Dimensions and general condition of any existing retaining structures adjacent to the corridor
- Other features such as culverts, underground services, existing rail platforms and level crossings

A total of 143 features were identified along the transit corridor during the site inspection. Geotechnical hazard plans showing the location of each feature are presented in Appendix E. A table summarising the location, type of each feature/hazard and a photographic record of each site is presented in Appendix F.

3.2.2 Key geotechnical hazards

The following key geotechnical hazards were identified during the site walkover.

3.2.2.1 Embankment instability

Evidence of rail embankment instability was observed along the transit corridor, including:

- Embankment instability noted at Polygons 19 and 22 (Appendix E, Figure 1) and Point 28 (Appendix E, Figure 2).

– Significant signs of embankment instability observed in proximity to the Risdon Road bridge overpass, including Line 82 and Points 85, 86, 87, 88 and 89 (Appendix E Figure 6).

3.2.2.2 Rock cuttings

Rock cuttings that may impact the project due to difficulty with corridor widening and upgrading were noted along the transit corridor, including:

– Dolerite cutting at Polygon 1, which also incorporates points 2, 3, 4 and 7 (Appendix E, Figure 1)
– Dolerite cutting at Line 41 (Appendix E Figure 2)
– Dolerite cutting at Line 62 (Appendix E Figure 3)
– Sandstone cutting at Line 67 (Appendix E Figure 4)

3.2.2.3 Slope instability

Evidence of slope instability along the corridor boundaries was observed along the transit corridor, including:

– Potential instability noted at Polygon 31 (Appendix E Figure 2)
– Minor rock falls noted at Points 42, 43 and 44 (Appendix E Figure 2)

3.2.2.4 Soft subgrade of existing rail embankment

Evidence of soft sub grade, including sections of ballast top up were observed along the transit corridor, including:

– Saturated soft subgrade noted at Point 45 (Appendix E Figure 2)
– Evidence of thicker ballast layers at Point 57 and 58 ((Appendix E Figure 3)
– Evidence of thicker ballast layers at Polygon 96 and Polygon 98 (Appendix E Figure 7)

3.2.3 Recommendations

The following recommendations for further geotechnical assessment of critical geotechnical hazards identified in section 3.2.2 are presented in Table 9 below. These investigations will inform the construction preparatory work required to provide a stable and safe surface for future transit vehicle use:

Table 9 Recommendations for further investigation of geotechnical hazards

Geotechnical Hazard	Recommendation
Embankment Stability	Undertake a formal landslide risk assessment of each site to assess the extent and nature of each instability feature, including material properties, failure mechanism and likely cause of instability.
Rock Cutting	Undertake geological mapping of each rock cutting face to formally assess the geological condition of the cutting face including rock type, strength, height, bedding, fracturing and cutting slope. The outcomes of the mapping could then be used for recommendations on excavatability conditions at each site.
Slope Instability	Undertake a formal landslide risk assessment of each site to assess the extent and nature of each instability feature including material properties, failure mechanism and likely cause of instability.
Soft Subgrade	Undertake intrusive investigations at each site to determine the existing material properties of the soft subgrade area, thickness of additional ballast material and extent of settlement and soft sub grade.

3.3 Structural

3.3.1 Risdon Road Rail Bridge

A Level 2 Bridge Assessment of the Risdon Road Rail Bridge was conducted on 11 June 2021. The scope of the inspection included identifying and quantifying observed defects and reporting on components requiring repair or maintenance.

3.3.1.1 General overview

The Risdon Road bridge was constructed in approximately 1914 and supported two rail tracks. The bridge comprises a single 19.5 m span, consisting of four riveted, wrought iron, open girders in two braced pairs. The deck consists of a wrought iron trough with 140 mm thick (approximate) concrete deck, and thin plated, riveted, wrought iron, open channel members on the underside. The girders are simply supported by steel bearing plates, sitting on in-situ concrete abutments with adjoining concrete wingwalls. The bridge deck now consists of a concrete pedestrian/cyclist thoroughfare on the south-western side, and the rail on the north-eastern side, separated by a steel chain link fence.

The nomenclature plan of the bridge is shown in Figure 14, below.

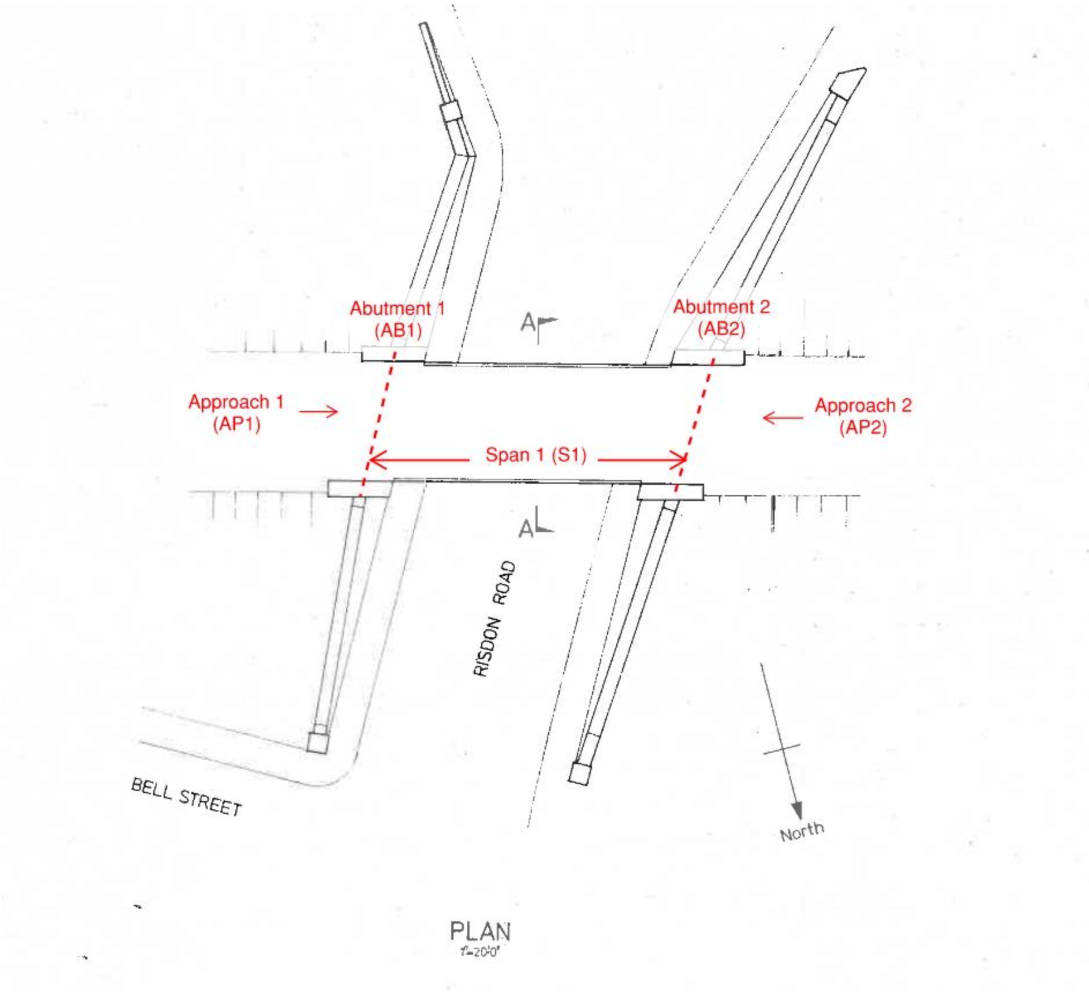


Figure 14 Risdon Road Bridge nomenclature plan

3.3.1.2 Methodology

The Level 2 Inspection was undertaken in accordance with the VicRoads Road Structures Inspection Manual (2018). The methodology followed in the inspections is summarised below:

- Visually inspect, assess, and document the condition of the bridge structure components in accordance with the VicRoads Road Structures Inspection Manual
- Identify and report on components with defects that may require closer monitoring, maintenance, or remediation
- Identify and report on components which may require a detailed engineering investigation (Level 3 Inspection)
- Obtain a photographic record of the bridge in its current condition

The VicRoads Road Structures Inspection Manual assigns each bridge component an alphanumeric "Component Number" which describes the component type and the material.

For each bridge element and material, the inspection manual provides qualitative descriptions for the four Condition States used when undertaking condition ratings. These Condition States are used to quantify the condition of each element by comparing the element against the description provided by VicRoads in the inspection manual. Each element is assigned a rating that totals to 100% and is proportioned based on the quantity of the element observed to be in each state.

The description of each condition state is different for each component number, however, generally the condition states can be generalised as follows:

– **Condition State 1:** Component is in good condition with little or no deterioration.
– **Condition State 2:** Component shows deterioration of a minor nature with primary supporting material showing the first signs of being affected.
– **Condition State 3:** Component shows advancing deterioration and loss of protection to the supporting material which is showing deterioration and minor loss of section. As a result, preventative maintenance may need to be considered by the asset manager to slow the rate of deterioration or improve the component condition.
– **Condition State 4:** Component shows advanced deterioration, loss of effective section to the primary supporting material, is acting differently to design or is showing signs of overstress. As a result, maintenance, repair, or replacement of the component will be required to improve the condition of the component.

The bridge elements were numbered in increasing order from Approach 1 to Approach 2, and from left to right, and top to bottom, when facing in the direction of Approach 1. The naming conventions of bridge elements can be found in Appendix D.

3.3.1.3 Access restrictions and limitations

Access to the bridge was gained through Risdon Road, and by foot over the bridge itself. The underside of the bridge was made accessible for safe visual inspection through the provision of traffic management services by Traffic Dynamix. The south-west bound lane was closed, and a scissor lift was utilised to observe the bridge superstructure at Abutment 1 (A1). Low voltage powerlines limited access to Abutment 2 (A2), however the north-east bound lane was closed, and the scissor lift was positioned as close as practicable to the abutment, without compromising safety. A camera with an appropriate lens and flash was utilised for the visual inspection.

The above-deck components were viewed from the Hobart Intercity Cycleway only and the components on the opposite side of the bridge containing the rail were viewed from the intermediate fence.

3.3.1.4 Results

The Risdon Road bridge was found to be in reasonable condition given the age of the structure. Key defects were observed in the superstructure of the bridge; however these are not deemed to impact the structural capacity of the bridge. Other defects have been identified in the structure which require maintenance or monitoring to prevent long-term deterioration.

Detailed inspection results, including condition ratings, observed defects, and key photographs are included in Appendix D. A summary of component condition ratings, general observations and observed defects are presented in the sections below.

General observations

The following general observations were made during the inspection:

– Previous repairs to the deck soffit to reduce corrosion include the addition of steel flashing. Water was observed to be streaming from the rivet holes of the steel flashing.
– Red staining on wrought iron members could be indicative of lead-based paint, typical of the time of construction, however, is likely rusting of the wrought iron. Further investigation will be required prior to repair and maintenance works.
– Bridge fencing appears to have been vertically extended. The wiring is undersized and rusting, with sections of the extended fencing not correctly installed. At Approach 1, the fence footing has been undermined.

- There was evidence of settlement at both bridge approaches. This settlement is likely due to consolidation of the embankment fill and underlying soil.

Key defects

Major defects, considered to exhibit a condition State 4, were observed in locations as summarised below:

- The footpaths on both approaches have failed, with tension cracking likely caused by settlement of embankment material.
- The pourable joints at both abutments are completely open, with sealant cracked and peeling away, and vertical displacement of adjacent concrete. The failed joint no longer provides adequate seal, allowing water and dirt to enter the joint. This presents a durability risk for the underlying elements and could lead to accelerated deterioration.
- The steel guardrails have corroded, with observed failure of paint surface coating. The kick plates have also deflected. The steel guard rails will likely need to be upgraded to meet current standards.
- Steel flashing is believed to have been installed to the edges of the deck soffit after significant corrosion was noticed in previous years. This corrosion is now extending out from under the flashing, with water pouring out through the rivet holes on the north-eastern side, the worst of which was observed approximately two metres from Abutment 2, with surface pitting and potential section loss. The extent of deterioration is unknown due to an obstructed view by the flashing.

General defects

Other defects observed during the inspection include:

- All bearing plates have debris present and possible loss of protective coating. The abutment ledges are wet from the failure of joints above. The wrought iron superstructure elements had general, localised corrosion with apparent failure of surface treatment in several locations.
- Deck soffit plates have corroded, with stalactites forming at centre joints. The end plate members of the deck soffit have severely corroded and deflected at both abutments, the most significant of which was observed at the north-western end.
- Some deck and girder rivets were missing, loose, or corroding.
- Minor cracking was observed in concrete abutments evident by calcification. Autogenous healing is believed to have sealed the cracking on the abutment walls, protecting the concrete from further deterioration.
- Larger cracking was observed in the following locations: at the interface of the southern wingwall and wingwall return at A1, causing spalling (believed to have been caused at time of construction); horizontal cracking at capping beam junction on the A2, northern wingwall; and at the interface between A1 and northern wingwall, with minor delamination.
- Possible buckling of two internal web stiffeners on the third and fourth girders was observed. However, this is likely attributed to warping of the stiffener plates at the time of installation. This could result in corrosion caused by water ingress, however, is not thought to be of concern.
- At Approach 1, the southern fence footing has scoured due to settlement.

3.3.1.5 Recommendations

Refer Section 4.2.1 for detailed recommendations.

3.3.1.6 Additional considerations

Other considerations requiring attention, not affecting structural integrity of the bridge, include:

- The concrete footpath may be replaced where failure has been observed. It is believed that this will be an ongoing issue due to the settlement of embankments. Long-term durability of the pavement will require geotechnical investigations.
- The guardrails and fencing should be assessed to ensure they meet safety requirements. If they are found to be of adequate design, corrosion repair to steel members and scour protection to footings should be undertaken. The extension to the existing fence should also be re-wired.

3.3.2 New Town Rivulet Bridge

A Level 2 Bridge Assessment of the New Town Rivulet Bridge was conducted on 27 August 2021. The scope of the inspection included identifying and quantifying observed defects and reporting on components requiring repair or maintenance.

3.3.2.1 General Overview

The New Town Rivulet bridge comprises a single span approximately 4.3 m long, consisting of six steel girders, restrained by four steel cross girders. The bridge utilises a concrete deck supported on simply supported girders. The abutments of the bridge have been modified since its construction, with half of the abutments being constructed of the original sandstone and the other half being constructed of concrete. Originally designed as a rail bridge, the bridge deck now consists of a concrete pedestrian/cyclist thoroughfare on the western side, and the rail on the eastern side, separated by a steel chain link fence.

The layout of the bridge is shown in Figure 15 below.

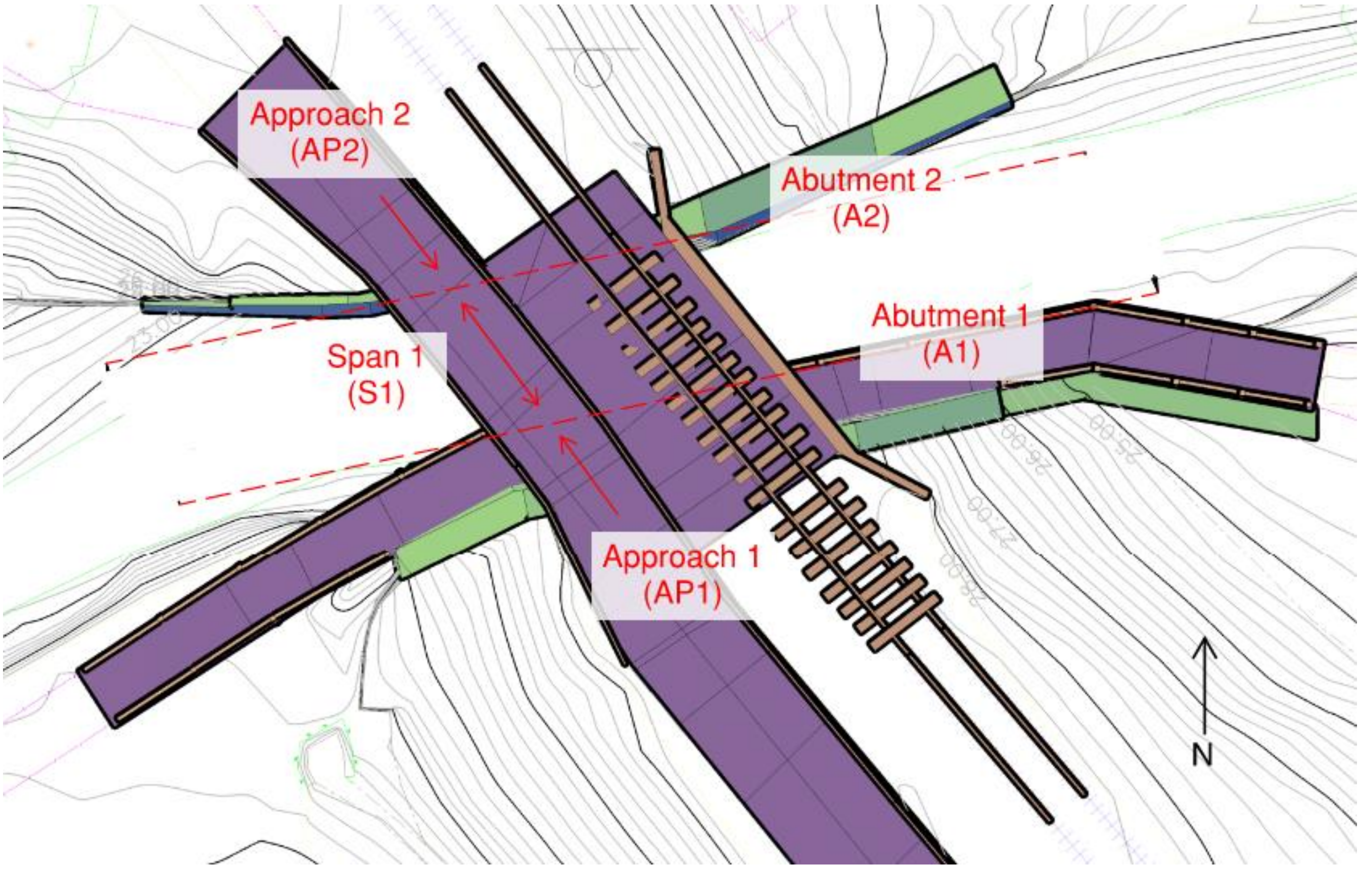


Figure 15 New Town Rivulet Bridge nomenclature plan

3.3.2.2 Methodology

Refer Section 3.3.1.2.

3.3.2.3 Access restrictions and limitations

Access to the bridge was gained via the footpath underneath the bridge, and by foot over the bridge itself. The footpath was attached to Abutment 1, hence the underside of the southern end of the bridge was inspected from the footpath. Due to a lack of access, a close-up inspection of the northern end of the bridge could not be conducted. The northern end of the bridge was inspected from the footpath with limited visibility. A camera with an appropriate lens was utilised to inspect this section of the bridge. The underside of the concrete deck was not visible due to a layer of steel sheeting welded to the top of the girders.

The components of the bridge above the deck were inspected from the Intercity Cycleway. The top surface of the concrete deck supporting the railway line could not be inspected due to ballast.

3.3.2.4 Results

The New Town Rivulet bridge was generally found to be in poor condition. The original sections of the substructure were found to be in very poor condition with the sandstone abutments showing signs of major degradation. All other elements of the bridge, including the concrete abutment and the superstructure, were noted to be in good condition with a few minor defects.

Detailed inspection results, including condition ratings, observed defects, and key photographs are included in Appendix D. A summary of component condition ratings, general observations and observed defects are presented in the sections below.

General observations

The following general observations were made during the inspection:

- The original sandstone substructure of the bridge has been upgraded to concrete abutments in the eastern section of the bridge, under the railway line. The sandstone sections of the substructure exhibited signs of major deterioration.
- Minor undermining was present under the footpath at the Approach 1. This is unlikely to cause any serious issues.
- Some impact damage was noted along the fence on either side of the footpath. The mesh from the top section of the fence was removed in sections of the fence.
- A timber pedestrian footpath was present at the south bank underneath the deck. The footpath was supported by steel members attached to Abutment 1.

Key defects

Major defects, considered to exhibit a condition State 4, were observed in locations as summarised below:

- The sandstone wingwall and abutment at Abutment 1 was found to have significant cracking at the mortar joints. The mortar at the joints has experienced significant deterioration that has led to cracks forming at the joints. Repairs undertaken in 2018, in the form of repointing, were evident. Despite the repairs, a significant amount of cracking is still present within the wall.
- The sandstone wingwall at Abutment 2 was found to have separated from the abutment with the wingwall leaning forward relative to the abutment wall. This suggest that significant cracking, coupled with the soil pressure from behind, has caused the wingwall to move independent of the abutment wall.
- Despite previous repairs in 2018, the sandstone abutment wall at Abutment 2 was also found to have significant deterioration with sever mortar cracking and weathered sandstone. The wall was found to exhibit significant bulging 2-3 m from the base. This has likely been caused due to the excessive cracking within the wall, reducing its load resisting capacity against the applied soil pressure. Significant repairs would be required to strengthen the wall.

General defects

Other defects observed during the inspection include:

- All bearing plates have debris present and possible loss of protective coating. A number of bearing plates were also found to have loose or missing bolts.
- Major deterioration was noted on the timber sleepers utilised at the retaining wall on the eastern end of the north bank.
- Intentional damage was noted on the concrete abutment walls due to cast in timbers that have since been removed. Abutment 2 also exhibited early signs of undermining.
- Minor rusting was noted on the steel girders, while the majority of the bolts connecting the girders to the deck were found to have experienced significant deterioration and corrosion. Localised surface rusting and section loss were also noted on the steel support members supporting the timber pedestrian footpath.

3.3.2.5 Recommendations

Refer Section 4.2.2 for detailed recommendations.

3.3.2.6 Additional considerations

Other considerations requiring attention, not affecting structural integrity of the bridge, include:

– The fencing should be assessed to ensure they meet safety requirements. Provided the fencing meets the appropriate safety requirements, the damaged sections of the fence would require re-wiring.

3.4 Culvert condition assessment

3.4.1 Site inspection

A high-level assessment of the existing drainage infrastructure along the track was conducted between 26-29 July 2021. The assessment was conducted along approximately 8 km of the Southern Line corridor between Macquarie Point and Northgate Shopping Centre. 41 existing culverts were found during the site inspection.

3.4.2 Culvert condition assessment

A visual inspection of each culvert along the track was undertaken (where possible) to determine the existing asset features and conditions. The inspection and collected data for each of the 41 culverts are included in the Culvert Data Collection Form and is included as Appendix B of this report, and summarised in Table 6. This is in accordance with the Culvert Inventory Collection Guideline (RMS October 2008). The existing culverts that were assessed are mapped in sketches and included as Appendix A of this report.

4. Post inspection

4.1 Rail recommendations

GHD has undertaken a high-level assessment based on information in the survey data, aerial imagery and 360º drone video footage of the rail corridor and adjacent bike path provided by UDM. The assessment includes:

– Assessment of the existing rail corridor to determine existing conditions and highlighting potential constraints associated with upgrading the existing rail corridor to accommodate light rail transit (LRT) services or bus rapid transit (BRT) services. This includes an initial space-proofing assessment to determine where the existing rail corridor can suitably accommodate LRT and BRT services and their minimum envelope requirements.
– Assessment of the existing track geometry (vertical and horizontal) to determine the maximum track speed allowance, highlighting locations where the LRT cannot achieve the desired 80 km/hr speed requirement.
– Determination of whether compliant station platforms can be provided in the proposed locations as per the PwC Northern Suburbs Transit Corridor Option Assessment Report.
– Identifying where bulk earthworks or clearing may be required to accommodate the proposed LRT or BRT services.
– Identifying where existing civil infrastructure (including but not limited to fencing, track side infrastructure, retaining structures, road safety barriers, road and rail level crossings and paths networks) require modification to accommodate the proposed LRT or BRT services.
– Identifying impacted services which will require relocation or additional protection.

4.1.1 Design parameters

Key geometric requirements adopted for the assessment of LRT and BRT are outlined in the tables below.

Table 10 Design Criteria for LRT

Criteria	Requirement	Reference
Maximum design speed	80 km/h	PwC Northern Suburbs Transit Corridor Transport Mode Study: Options Assessment Report – Section 4.3
Rail Gauge	1435 mm	Yarra Trams Standard – Infrastructure – Tram Track Design (CE-021-ST-0035), cl. 4.2.3.1
Minimum Horizontal Curve Radii (Mainline)	500 m	Yarra Trams Standard – Infrastructure – Tram Track Design (CE-021-ST-0035), Appendix B2
Maximum Vertical Gradient	6.67%	Yarra Trams Standard – Infrastructure – Tram Track Design (CE-021-ST-0035), Appendix B8
Maximum Applied Cant	100 mm	Yarra Trams Standard – Infrastructure – Tram Track Design (CE-021-ST-0035), Appendix B10
Maximum Cant Deficiency	85 mm	Yarra Trams Standard – Infrastructure – Tram Track Design (CE-021-ST-0035), Appendix B4
Minimum Platform length	33 m	Yarra Trams Standard – Infrastructure – Tram Stop Platform Design (CE-021-ST-0012), Table 3
Minimum Platform width	3.1 m	Yarra Trams Standard – Infrastructure – Tram Stop Platform Design (CE-021-ST-0012), Table 3
Platform height above rail	290 mm	Yarra Trams Standard – Infrastructure – Tram Stop Platform Design (CE-021-ST-0012), Table 3
Additional tangent track beyond each end of platform to account for curve effects	Min. 15 m	Assumption – approx. half the length of vehicle

Criteria	Requirement	Reference
Absolute maximum vertical grade at tram stop	2.50%	Yarra Trams Standard – Infrastructure – Tram Track Design (CE-021-ST-0035), Appendix B8
Desirable maximum vertical grade at tram stop	0.50%	Yarra Trams Standard – Infrastructure – Tram Track Design (CE-021-ST-0035), Appendix B8

Table 11 Design Criteria for BRT

Criteria	Requirement	Reference
Traffic Lane Width	Min. 3.5 m	Austroads Guide to Road Design Part 3: Geometric Design, table 4.3
Shoulder Width	Min. 1.5 m (Note: Potential to reduce road shoulder to minimum 0.5 m width with the addition of road barriers however reducing road shoulders will compromise and reduce the vehicle design speeds.)	Austroads Guide to Road Design Part 3: Geometric Design, Clause 4.3.2
Verge Width	Min. 1 m (Note: Verge width shall be widened to a min. 1.5 m where required to accommodate road safety barriers.)	Austroads Guide to Road Design Part 3: Geometric Design, table 4.9
Cross Fall	Typ. 3%	Austroads Guide to Road Design Part 3: Geometric Design, Clause 4.2.2

4.1.2 Transit lane geometry

An analysis of the existing transit lane geometry was undertaken based on the aerial imagery and survey data supplied by UDM. The extent of the analysis is between Macquarie Point Station to Glenorchy Central Station. This was to allow for desktop timetabling and the determination of passing loop locations (refer Section 4.1.7 for details).

It should be noted the survey data and the updated aerial imagery supplied by UDM on 16 August 2021 covers the rail corridor from McVilly Drive to Peltro Street. As the extremities are outside of the proposed Macquarie Point Station, older aerial images (dated 16 July 2021) were used to complete the analysis. Some slippage may be expected at the interface between the two aerial images; however discrepancies are expected to have minimal impact for the purposes of this high-level assessment.

A chainage value of 0 has also been assigned to the start of the Macquarie Point platform (refer Section 1.1.1 for detailed platform locations).

For the light rail option, the design parameters listed within Victorian Yarra Trams Track Design standard (CE-021-ST-0035) were used for the development of horizontal and vertical track geometry along the corridor. At present, the TasRail standards are suited to heavy rail only and therefore not representative of the design parameters for light rail. The Yarra Trams standard is a mature, well developed standard that is also publicly accessible. Although Yarra Trams standard do contain some compromises due to the inherited historic constraints in Melbourne, GHD is aware of these issues and have adopted the normal (not compromised) design parameters. GHD also has experience in the application of the mainstream international light rail standards and other interstate standards. The parameters adopted in this project are also consistent with those international standards, and are not significantly different to the interstate standards.

For the bus transit option, Austroad standards have been adopted as a basis for design for horizontal and vertical road geometry however these parameters are primarily chosen on the basis of safety and factor design considerations including but not limited to design speed, sign distance, stopping distance, horizontal curve radii, pavement superelevation and traffic lane width.

4.1.2.1 Horizontal geometry

The supplied aerial imagery was used to develop the horizontal alignment for the route, which follows the existing rail geometry as much as possible.

Appendix I depicts the route alignment between Macquarie Point Station to Glenorchy Central Station, with all horizontal curves and associated radii annotated.

Light rail geometry

In the existing rail geometry, there are 13 horizontal curves within the study area that have radii smaller than 500 m; these are less than the minimum allowable mainline horizontal curve radii, according to Yarra Trams Standard – Infrastructure – Tram Track Design (CE-021-ST-0035), Appendix I. Nevertheless, it should be noted that light rail vehicles are typically capable of traversing horizontal curves with much tighter radii (~25 m), such as in city streets, albeit this is typically accompanied by use of embedded tracks which reduce the probability of lateral movement of the rails.

According to the curve speed calculations, it was found that any horizontal curve with a radius less than 470 m will not achieve the desired running speed of 80 km/h, and a speed restriction would be required. The horizontal curves requiring speed restrictions are marked in Appendix I. The sharpest horizontal curve radii for the corridor is approximately 110 m, which only support a speed of up to 30 km/h. The sections of route with flatter curve radii and long straights can theoretically support speeds of up to 80 km/h, subject to any additional curves required to accommodate the new stations and other site constraints such as reduced clearances.

Bus transit geometry

In accordance with Austroads guide to road design Part 3 a typical posted speed limits for a once-way service road is 50 km/h, however it's acknowledged this design speed can increase and decrease based on the maximum superelevation's and curve radii. As a general indication for roads on which vehicle speeds are largely unaffected by the horizontal alignment a minimum radius of 200m corresponds to a design speed of 70 km/h and a posted speed limit of 60 km/h. Given the existing rail corridor has curves with a smaller radius then 200m it's expected a speed limit less then 60km/h will be required through lengths of the corridor however these restrictions are subject to further design development as they are subject to specific geometric conditions (superelevation, curve radii etc), and sight distance requirements. It's anticipated that the BRT corridor will operate at speeds similar or less then that of the LRT.

4.1.2.2 Vertical geometry

Based on survey data, the existing gradient is relatively flat with a maximum of 2.6% (longitudinal section is provided in Appendix J). When solely considering the vertical gradient, this is well within the operating limits that light rail vehicles and buses are typically designed for, and for light rail it is well within the maximum allowable gradient of 6.67% as per the Yarra Trams track design standard. However, it should be noted that the gradient also has an impact on the power requirements of the LRT / BRT vehicles. Given the assumption that the proposed LRT / BRT could possibly operate as a wire-free, battery electric system, the power requirements should therefore be investigated and assessed in later stages of the project (electrical assessment is not part of GHD's scope of works).

It is not expected that replacement or reconditioning of the tracks would substantially change the gradients from existing.

Note when assessing the existing vertical gradient of the corridor, the top of rail levels from the survey were used. The section of track underneath Tasman Bridge was not picked up by the survey and therefore an assumed gradient was implied based on the rail levels on either end.

Note that vertical geometry has not been assessed for sight distance, which may limit maximum operation speeds.

4.1.3 Minimum envelope requirements

Geometric and clearance requirements have been adopted based on relevant design standards to determine the minimum envelope requirements as outlined in the sections below.

4.1.3.1 Light Rail Transit (LRT)

A minimum overall light rail corridor width of 8.5 m has been adopted for single track light rail transit with geometric considerations made for track gauge and structural clearance as per Yarra Trams standard drawing T9000. The track formation has been widened to allow for track-side infrastructure including drainage, overhead line equipment (OLE) structures (if required, for electrification) and combined service route (CSR) with a nominal 1 m wide shoulder provided to embankments. The 1 m shoulder provides a safe path for maintenance staff clear of the light rail vehicles and also acts as an emergency egress path, in the case of vehicle evacuation.

A nominal width of 1.7 m has been assumed for CSR and a drainage swale to service both the shared user path and the light rail track. This also provides a safety clearance margin between the shared user path fence and the light rail vehicles moving at up to 80 km/h.

The typical cross-section of the single-track rail corridor is shown in Figure 16 with a one-way crossfall adopted over a crown formation to minimise drainage infrastructure requirements and reduce the overall rail corridor width.

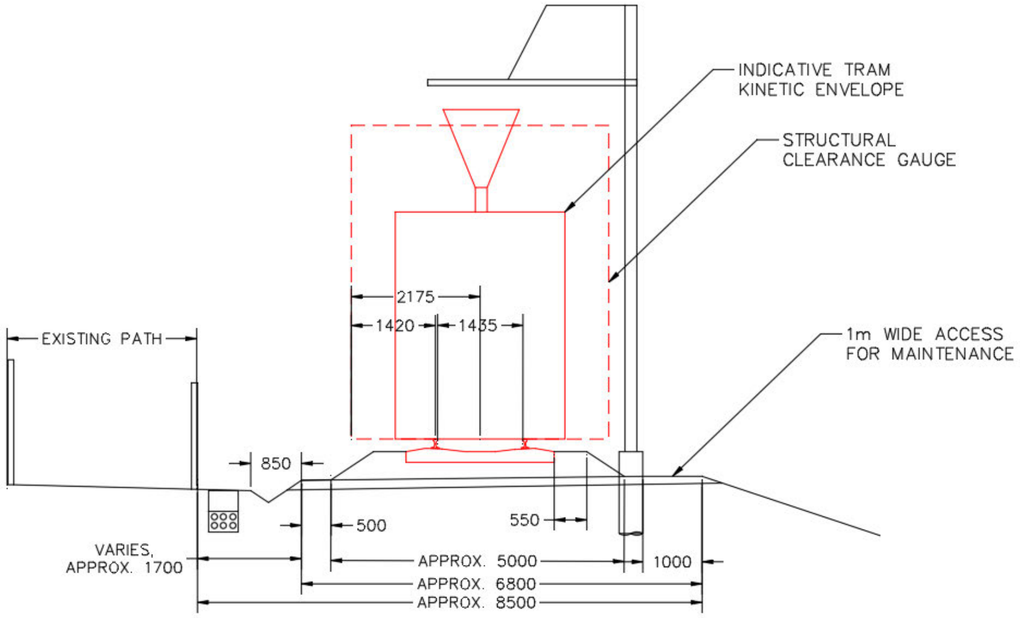


Figure 16 Typical section of LRT rail corridor

4.1.3.2 Bus Rapid Transit (BRT)

Similarly, a minimum overall single lane carriageway width of 8.5 m has been adopted for BRT based on the minimum requirements specified in Austroads Guide to Road Design Part 3. The roadway considers a minimum 3.5 m wide bus lane with 1.5 m wide sealed shoulders and minimum 1.0 m wide road verge as shown in Figure 17, which depicts two buses making a passing manoeuvre on a single carriageway.

Austroads Guide to Road Design Part 3 table 4.5 provides guidance around single lane carriageway widths on high speed rural roads where a total carriageway width of 8.7m is specified, which considers a minimum 3.7 m wide traffic lane and 2.5 m wide shoulders. It is acknowledged that these requirements are specific to rural roads and a design vehicle equivalent to a car. While 8.5m has been adopted as the single lane carriageway width, there is potential the carriageway width will need to be increased subject to further detailed design to account for the following considerations;

– Additional width for tracking or large vehicles particularly swept paths for passing buses manoeuvring to the road shoulders to account for the bus vehicle tail swing or front overhang to clear any road verge infrastructure including but not limited to road safety barriers, fencing, road signals etc.
– Widening of the road shoulders for section of curved roads, subject to factors including radius of curve, vehicle length, width and clearance requirements.

– Mitigating the potential for head-on accidents and providing bus operators and passengers with a satisfactory level of services, comfort and safety.

While Austroads provides commentary around minimal carriageway widths for single land carriageway, this option is not feasible as it will compromise the performance, safety, reliability and overall comfort for the driver and passengers utilising the rapid bus transit system. The single lane carriageway presents an increased risk in front on collision, while practically it's expected buses will need to reduce speed significantly, assumed to be in the order of 20 km/h or less, to perform these passing maneuverers, however this speed is also subject to site conditions and can very subject to where along the corridor these passing movement will take place.

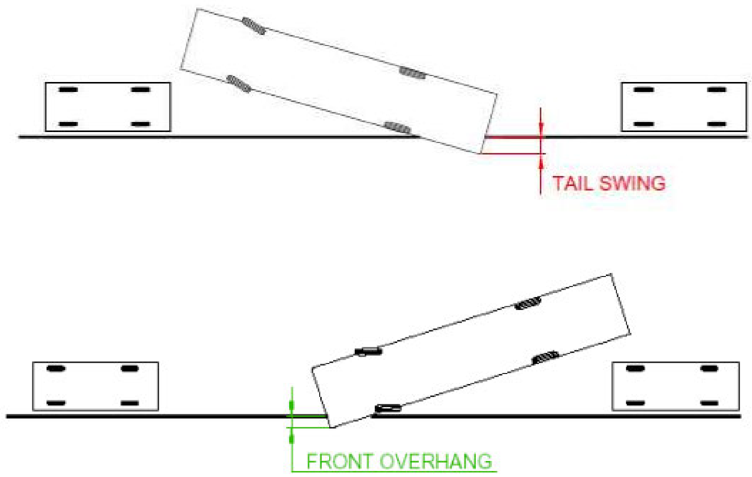


Figure 17: Extract from NSW State Transit Bus Infrastructure Guide

A one-way crossfall has been considered to minimise drainage infrastructure requirements. However. road verge widths will vary subject to drainage and batter requirements and may need to be increased beyond the minimum 1.0 m specified to accommodate infrastructure located within the road verge. In critically constrained locations the overall roadway width can be reduced with the addition of road safety barriers and reducing the sealed shoulder width to a minimum 0.5 m; however, reduced shoulders can compromise the roadway operational speed and safety resulting from non-compliant sight distance requirements and user error.

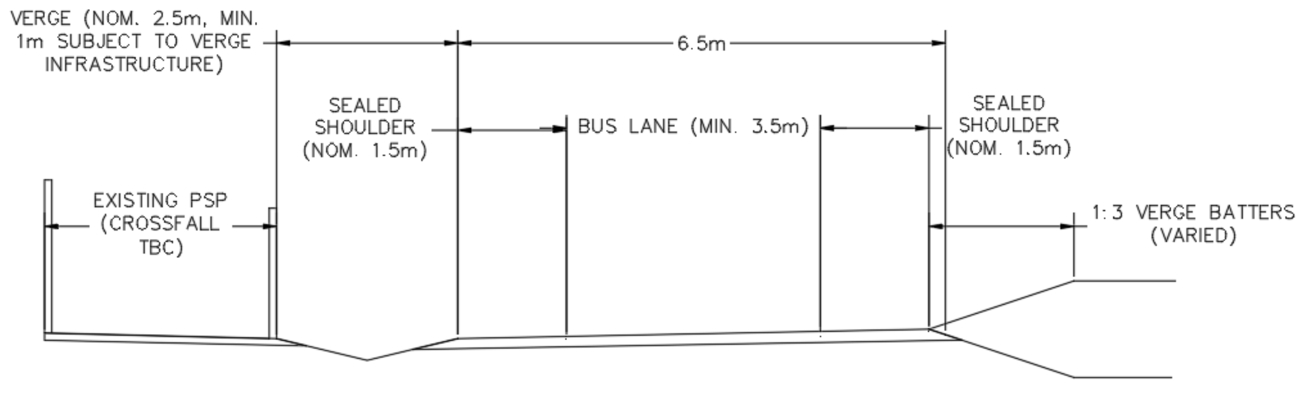


Figure 18 Typical section of BRT roadway

4.1.4 Existing rail corridor condition

As detailed in section 3.1 of this document, most of the existing infrastructure along the rail corridor, such as the rails, ballast and sleepers, are in poor condition and will require complete replacement. Given the additional operational and cost issues relating to the difference in rail gauge (narrow vs standard), it is strongly recommended that the track gauge is changed to standard gauge.

The existing cycle path located adjacent to the proposed rail corridor generally has a 3 m to 3.5 m path width which is compliant with AustRoads Guide to Road Design Part 6 requirements which specify an absolute minimum shared path width of 3 m. If a separated two-way path was to be considered the path would require widening to a desirable minimum width of 4.5m, however this is not recommended increasing the cycle path would reduce the width available on what is an already notably constrained rail corridor.

4.1.5 Corridor width

Analysis of the survey data and drone video footage generally shows that the existing rail corridor is not wide enough to accommodate the recommended 8.5 m single track / lane corridor width required to comply with the geometric and clearance requirements outlined in Yarra Trams and Austroads design standards. A key reason to the widening is because the introduction of the cycleway beside the rail corridor had previously led to the removal of one of the rail tracks. This meant the width of the corridor was reduced significantly along numerous sections, and thus there is now less available space for the transit service.

The existing rail corridor width varies along the alignment, Table 12 demonstrates the expected level of works and effort required to accommodate the widening of the rail corridor along various length of the alignment, however it’s recognised these works are based on the adopted 8.5 m wide rail corridor and is subject to change following subsequent design development. Based on the findings major earthworks and civil works will be required along most of the existing alignment to widen the rail corridor and support new rail infrastructure, (refer to Appendix H for cross-sections at these critical locations).

Note that the ideal configuration for the transit service would be a fully duplicated corridor with a dedicated track / lane in each direction. Full duplication would allow for the most time and operationally efficient service with minimal delays. However, this also requires the overall corridor to be wider (up to approx. 20m wide at station platforms). Refer to Section 4.1.7 for further detail on passing loops.

Table 12 Critically Constrained Rail Corridor Locations

Category	Criteria for Category (single lane corridor only, with duplication at passing locations based on a 10-minute headway)
MINOR	Areas along the alignment where the existing rail corridor is wide enough to accommodate the 8.5 m adopted corridor width. General grubbing and regrading required to build rail earthworks foundation, capping and ballast.
MODERATE	Areas along the alignment where the existing rail corridor is wide enough to accommodate the 8.5 m adopted corridor width however significant civil works is required. Generally this category includes including but not limited to: • Bulk earthworks cut / fill. • Relocation of existing verge infrastructure /services. • Retaining structures required where batters can not tie into existing surfaces within the 8.5m wide corridor footprint.
MAJOR	Areas along the alignment where the existing rail corridor is not wide enough to accommodate the 8.5 m adopted corridor width and significant civil works is required to widen the rail corridor. Generally this category includes but is not limited to: • Where modification of the existing cycle path or adjacent local roads and road verge infrastructure is required. • Where bulk earthworks cut / fill will be required beyond the existing rail corridor footprint.
CRITICAL	Critically constrained locations where the existing rail corridor is bound by significant infrastructure and major civil and/or structural works are required. Generally this category includes but is not limited to: • Rail Bridges or Road bridges. • Existing steep embankments where significant earthworks fill will be required. • Where potential land acquisition may be required.

Section ID	Category	Indicative Chainage Range	Length of corridor (km)	Approx. Rail Corridor Width (m)	Comments
1	CRITICAL	550 - 750	200	7.95	The rail corridor footprint will extend over the existing fence line, acknowledging it has been assumed the fence line sits on the existing property boundary. Risk: Relocation of the fence will be required and potential land acquisition subject to whether the fence is located on the property boundary.
	MODERATE	750 – 825	75	Varied	Bulk fill required to widen rail corridor.

Section ID	Category	Indicative Chainage Range	Length of corridor (km)	Approx. Rail Corridor Width (m)	Comments
	MAJOR	825 - 1000	175	Varied	The existing rail corridor is runs adjacent to an existing building, carpark facility and access road off Tasman Highway. Risk: Bulk earthworks is required to widen the corridor, to achieve this the existing carpark facility and access road will require modification/relocation. The rail corridor footprint may fall beyond the property boundary and land acquisition may be required, however this will need to be further investigated in subsequent design development.
	MAJOR	1000 - 1725	725	Varied	Significant bulk earthworks fill required through this extent to widen the rail corridor with existing steep batters located adjacent to the existing rail corridor. Risk: The existing rail corridor runs adjacent to the River Derwent and the bulk earthworks may extend into the river to widen the corridor and provide the required stable grades as per design standards.
	CRITICAL	1725 - 1750 (Tasman Hwy bridge)	25	5.65	The existing rail corridor is located flush between the existing cycle path and the Tasman bridge pier supports which currently fall within the tram light rail structural clearance zone. Risk: To widen the rail corridor it’s highly anticipated the rail alignment will require relocating closer to the existing cycle path with modifications to relocate and/or reduce the cycle path width to ensure the Tasman Bridge piers and any additional pier protection infrastructure falls beyond the structural clearance zone.
2	CRITICAL	1750 - 2150	400	6.75 – 7.3	The existing rail corridor is located flush between an existing local / access road, parking facilities, and the Derwent Mercantile Collegiate Rowing Club and retaining structure and /or steep rock face embankments. Additionally through this length is where the Botanical Gardens Station is proposed to be located and dual corridor width is required Risk: To widen the corridor the adjacent local road and associated infrastructure (e.g. lighting, electrical poles, ITS service etc.) will need to be locally relocated or the retaining structure will need to be relocated and designed flush to the existing cycle path with upgraded hazard / fall protection required for pedestrian and cyclist safety. Refer to section 4.1.6.1 for high level review at this location.
	CRITICAL	2150-2650	500	4.65 - 8.5	The existing rail corridor is located flush between the Domain Highway / cycle path and the River Derwent. Additionally as this area is located within the range of the Botanical Gardens Station is proposed to be located and dual corridor width is required Risk: It’s anticipated that the bulk earthworks footprint required to widen the rail corridor will extend into the Derwent River and is subject to various environmental considerations, constraints and/or limitations. Additionally retaining structures may be required through this extent of the alignment and the existing unpaved path located adjacent to the bay will need to be removed to accommodate widening of the rail corridor.
3	MAJOR	2650- 3650	1000	Varied	Significant bulk earthworks fill required through this extent to widen the rail corridor with existing steep batters located adjacent to the existing rail corridor.

Section ID	Category	Indicative Chainage Range	Length of corridor (km)	Approx. Rail Corridor Width (m)	Comments
					Risk: The existing rail corridor runs adjacent to the River Derwent and the bulk earthworks may extend into the river to widen the corridor and provide the required stable grades as per design standards.
4	CRITICAL	3650 - 3875 (Brooker Hwy Road Bridge)	225	5.75	Existing rail corridor is located flush between the Brooker Hwy bridge superstructure (bridge abutment and piers) and the existing shared path. Additionally existing private propertied are located on the eastern side of the rail corridor on the approach to Brooker Hwy bridge. Risk: Currently the bridge abutment falls within the structural clearance zone as per Yarra Trams standard drawing T9000. Further investigation is required to determine if the rail alignment can be modified to allow the bridge abutment to fall beyond the structural clearance zone. To accommodate the shift in rail alignment, the adjacent cycle path will need to be locally realigned closer to the bridge piers or path width reduced.
5	CRITICAL	3875 –4440	565	8.50	Rail corridor footprint falls flush with the edge of the existing adjacent Bell Street Road pavement clashing with multiple road verge infrastructure (lighting poles, power poles and overhead lines, various utility pits and retaining structures. The path located on the other side of the corridor backs onto what has been assumed as private property. Risk: With insufficient road verge located on the eastbound side of Bell Street to accommodate road verge infrastructure, land acquisition of the properties on the south side of the rail corridor is required to locally shift the shared path and rail corridor south to avoid conflict with the existing road verge infrastructure.
6	CRITICAL	4400 – 4750 (Risdon Rd Rail Bridge)	350	5.25	The existing Risdon Road rail bridge is currently not wide enough to support the minimum rail corridor width of 8.5 m adopted in this investigation. It's acknowledged additional corridor width is required to provide derailment infrastructure and a typical 1 m wide maintenance walkway within the rail corridor. Additionally, current 1(V):1.5(H) embankments existing on the approach and departure to the rail bridge. These batters will need to be increased to accommodate widening of the rail corridor. Risk: In addition to the outcomes of a structural capacity assessment the existing rail bridge will require upgrading to comply with the minimum geometric and clearance requirements. Additionally it's highly anticipated retaining walls or other soil stabilisation techniques will be required where the existing embankments batters need to be increased.
7	CRITICAL	4750 – 5100 (Tower Rd Rail Bridge)	350	7.00	The existing rail corridor runs flush between the existing adjacent cycle path and Tower Road bridge piers. Subject to further investigation of the track alignment the bridge piers currently fall within the minimum structural clearance required as per Yarra Tram standard drawing T9000. Additionally, an existing vertical clearance of 4.6 m is achieved from what has been assumed as the road pavement level in the survey data. This is non-compliant with the minimum 5.3 m clearance required from top of rail to the bridge superstructure (soffit level) as specified with AS5100.1 standard. Furthermore, Yarra Trams requires a minimum 5 m trolley overhead wire height as the support points. Risk: The rail alignment will need to be lowered to achieve the minimum structural clearance required from top of rail to the bridge soffit level. This will increase the overall rail corridor

Section ID	Category	Indicative Chainage Range	Length of corridor (km)	Approx. Rail Corridor Width (m)	Comments
					earthworks footprint, resulting in a larger impact to the existing path or bridge piers / superstructure. Further investigation is required to determine rail levels and impacts to the existing bridge structure, however, it's anticipated the existing Tower Road rail bridge will require a level of upgrading / re-design.
	MAJOR	5100 - 5300	200	6.57	Significant bulk earthworks fill required through this extent to widen the rail corridor with existing steep batters located adjacent to the existing rail corridor. Risk: The existing corridor it boarded by various private properties and local roads. To accommodate the widening of the rail corridor through this extent it's anticipated retaining structures will be required or modification to the existing cycle path including relocation and/or reduce the cycle path width.
8	CRITICAL	5300 – 5450 (Waterway Rail Bridge)	150	5.25	The existing rail bridge is currently not wide enough to support the minimum rail corridor width of 8.5 m adopted in this investigation. It's acknowledged additional corridor width is required to provide derailment infrastructure and a typical 1 m wide maintenance walkway within the rail corridor. Additionally, current 1(V):1.5(H) embankments exist on the approach and departure to the rail bridge. These batters will need to be increased to accommodate widening of the rail corridor. Risk: In addition to the outcomes of a structural capacity assessment the existing rail bridge will require upgrading to comply with the minimum geometric and clearance requirements. Additionally, it is highly anticipated retaining walls or other soil stabilisation techniques will be required where the existing embankments batters need to be increased.
	MINOR	5450 - 7700	2250	Varied	General earthworks required through this area to build up the rail earthworks foundation, capping and ballast with multiple at grade crossings required through this extent and potential service relocation and/ or protections required subject to subsequent design development.
	MODERATE	7700 - 8000	300	8.0	The existing rail corridor it runs flush between the existing adjacent cycle path and private properties / industrial facilities located on both sides of the rail corridor. Risk: There is potential that the rail corridor footprint will extend beyond the rail corridor boundary in which case to avoid land acquisition the existing cycle path width will need to be reduce subject to subsequent design development.
	MINOR	8000 - 8350	350	Varied	General earthworks required through this area to build up the rail earthworks foundation, capping and ballast with multiple at grade crossings required through this extent and potential service relocation and/ or protections required subject to subsequent design development.

4.1.6 Stations / Platforms

Initial platform locations have been assumed from Figure 6 of the PwC Northern Suburbs Transit Corridor Transport Mode Study: Options Assessment Report.

Based on the limits of study area, track geometry and site constraints, the relevant station locations were further investigated and adjusted as appropriate, with feasibility being the key consideration.

The factors which affect feasibility of the station locations include:

– Available corridor width
– Whether there is adequate length of tangent track to accommodate a straight platform, including additional length to account for curve effects resulting in the vehicles being too close to, or possibly hitting, the platform edge
– Possible impacts to existing infrastructure within the rail corridor upon the placement of platform

The existing vertical gradient of the track at each station was also investigated. It was found that the existing gradient through the proposed platforms are at or below 1.0%, which is above the desirable limit of 0.50% but also well under the absolute allowable maximum of 2.50%. However, the survey data shows that there are minor undulations in the existing track through the proposed platform locations. These should be rectified to ensure the gradient is constant through the full length of the platform (Yarra Trams Standard CE-021-ST-0012, cl. 4.3.1.10).

A summary list of the stations considered in this assessment is provided in Table 13.

Table 13 Summary of Proposed Stations

Station ID	Location	Approx. Chainage (m)	Passing loop	Notes / Comments
1	Macquarie Point	0 – 33	Survey data not available for this extent – subject to further investigation	A straight platform is possible. However, platform / tracks will likely cross the existing bitumen road leading out of the Royal Hobart Regatta. Existing gradient data not available.
2	Botanical Gardens	2083 – 2116	Duplication for passing loops and a platform can be achieved through this station area with substantial civil works and relocation of existing infrastructure.	Existing platform is curved and is located within an existing R200 m curve. To achieve a straight platform required by modern design standards, significant widening of the existing rail corridor will be required. This includes land reclamation (i.e. on the side of the water). Obtaining the relevant environmental approvals may be difficult. Alternatively, the platform could be located further east near the Japanese Gardens. Placing the platform further west is not recommended due to the distance (300 m) to the Botanical Gardens main entrance / car park. However, at this location, some of the existing trees and vegetation on the southern side of transit corridor will likely require removal. Existing vertical gradient varies between 0.267% and -0.576%.
3	New Town	4263 – 4296	Duplication for a passing loop and station platforms cannot be achieved through this extent without relocating the adjacent roadway or encroaching on adjacent properties. Dual tracks can be achieved through this chainage range however further investigation is required as	Platform to be located at the eastern end of existing platform, where the horizontal alignment geometry is straight. Note that the existing platform will need to be reconfigured to suit the proposed alignment and upgraded to achieve DDA compliance. Existing vertical gradient varies between 0.783% and 0.958%.

Station ID	Location	Approx. Chainage (m)	Passing loop	Notes / Comments
			greater length of track duplication would be required beyond what can currently be achieved to run a reliable service at this station location	
4	Albert Road	5639 – 5672	Duplication for passing loops and a platform can be achieved through this station area with civil works and potential relocation of existing carpark and roadside infrastructure required.	A straight platform is possible on either end of the Albert Road level crossing. Platform proposed to be located on the southern side of level crossing so that it is closer to Station Street Reserve. Existing vertical gradient varies between -0.506% and -0.902%.
5	Derwent Park Road	6730 – 6763	Duplication for a passing loop and station platforms cannot be achieved through this extent without relocating / modifying the adjacent cycleway or encroaching on adjacent properties.	A straight platform is possible on either end of the Derwent Park Road level crossing. Platform proposed to be located on the southern side of crossing as the survey data suggests there is more available space for the platform. Existing vertical gradient varies between -0.085% and 0.194%.
6	Hobart Showground	7506 – 7539	Duplication for a passing loop and station platforms cannot be achieved through this extent without relocation/modification of the adjacent roadway or cycle path.	Locate platform on to the east of showgrounds (near Howard Road) to avoid horizontal curve. Existing vertical gradient varies between 0.841% and 1.010%
7	Glenorchy Central	8314 – 8347	Duplication for passing loops and a platform can be achieved through this station area with civil works and potential relocation/ modification of existing adjacent road and road verge infrastructure required located to the north of the corridor.	The corridor width is highly constrained due to existing platform / retaining structure and existing tracks on the northern side (leading into the Transport Museum), as well as the cycling path to the south. Local realignment of cycling path towards the south will be required. Existing vertical gradient varies between -0.132% and -0.079%.

4.1.6.1 High level review of Botanical Gardens

In accordance with Yarra Trams standards, light rail platforms are required to be constructed through sections of straight track. This cannot be achieved where the existing platform is located, recognising the existing platform is curved and located on an existing R200 m curve.

For this reason, it is highly recommended the Botanical Gardens station is constructed east of its current location through the straight section of track as shown in Figure 19. It is acknowledged the existing rail corridor through this section is significantly constrained by Domain Highway and an adjacent access / local road providing vehicle access to Derwent Mercantile Collegiate Rowing Club with adjacent steep rock face embankments.

The existing rail corridor will need to be significantly widened in this area to accommodate the track platform required to run a light rail service through the existing rail alignment. It is currently unknown the level of vegetation clearing and earthworks excavation effort required to cut away the embankment located to the east of the rail corridor to accommodate the corridor widening. Additionally, a large retaining structure would be required and modifications to Domain Highway including but not limited to the addition of road safety barriers and relocation of various road verge infrastructure including street lighting, drainage, major signs, and potentially underground services.

Alternatively, the adjacent access road located to the west of the rail corridor will require relocation to the north. Additionally, a large number of existing road verge infrastructure items will require relocation including but not limited to fencing, retaining structures, overhead power lines and power poles, signage and potentially underground services. Refer to Figure 20 which shows the existing cross-sections through various locations along the rail alignment and platform location.

[redacted]

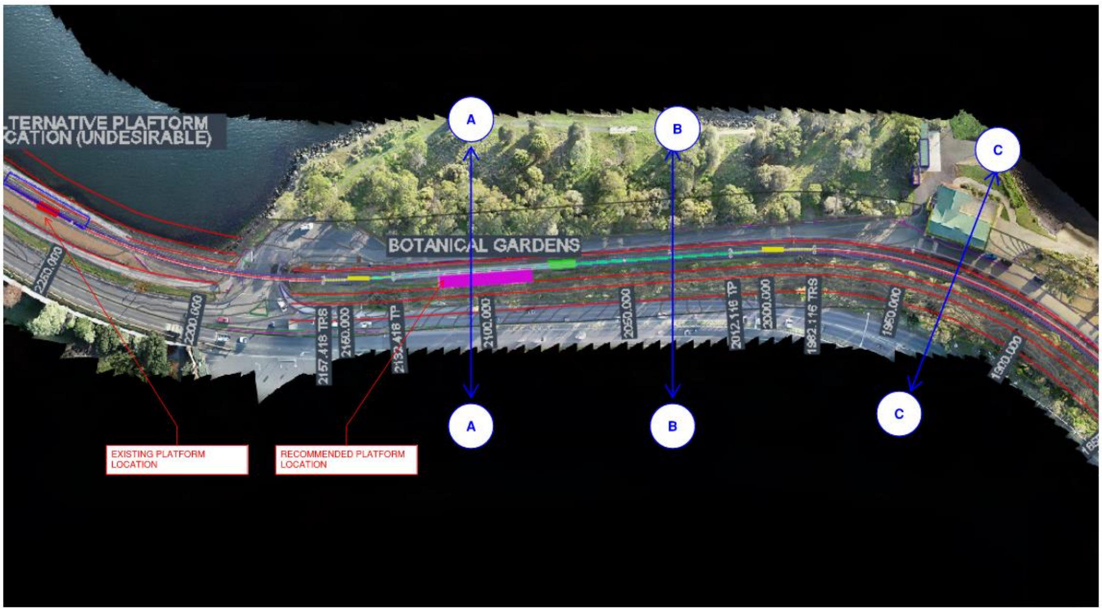


Figure 19 Recommended Botanical Gardens Platform Location

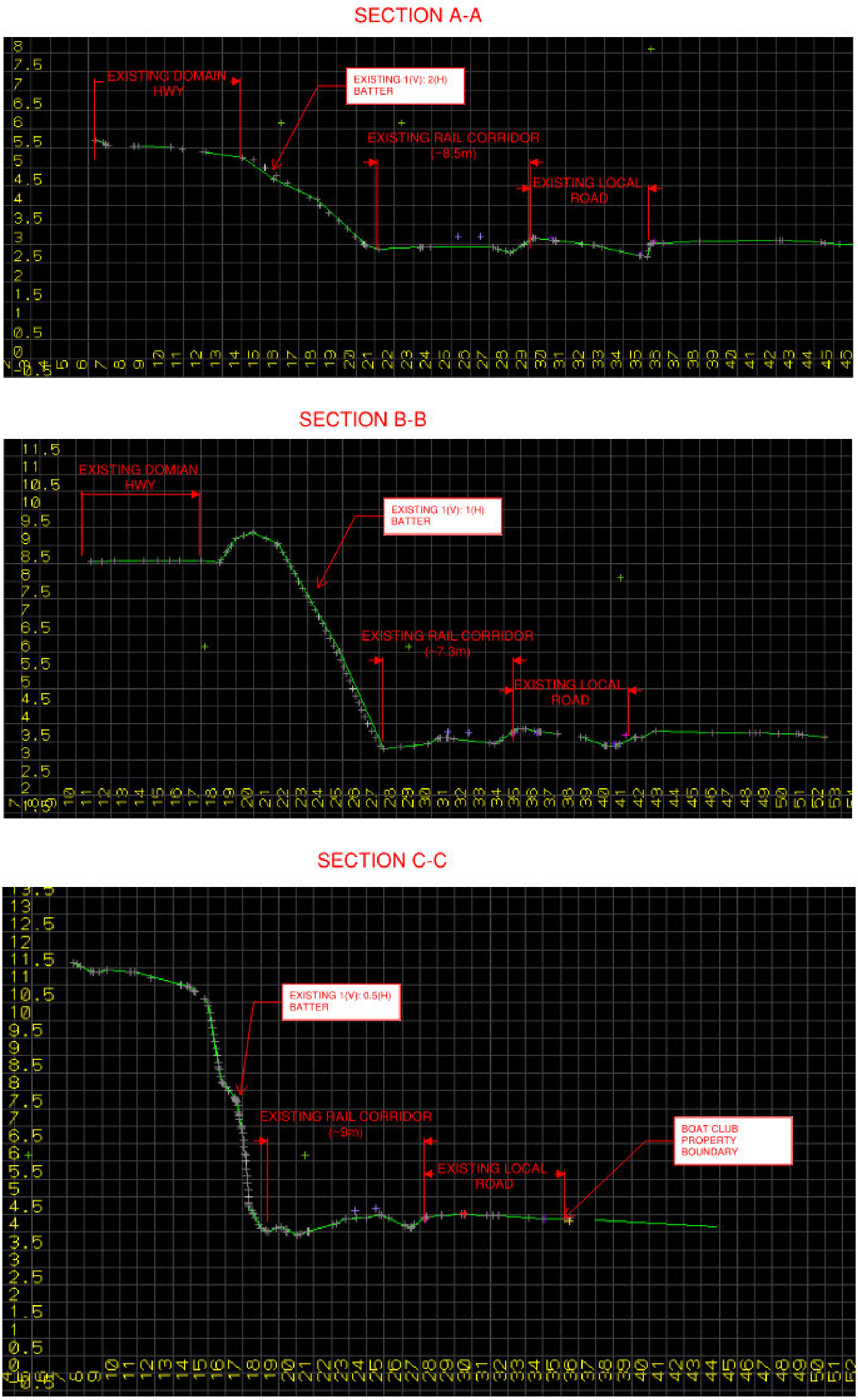


Figure 20 ***Botanical Gardens Cross-Sections***

4.1.7 Passing loops

The existing rail corridor was assessed to determine suitable and feasible track passing loop and station locations along the alignment. The factors which affect feasibility of the passing loop locations include:

- Available corridor width
- Possible impacts to existing infrastructure within and beyond the extent of the rail corridor
- Length of the passing loop which can be achieved subject to available corridor width. Longer passing loops are always more desirable to allow flexibility for delays during operation, for example traffic signals and unexpected events
- The timing of outbound and inbound services

Where possible, passing loops have been located at stations as highlighted in Section 1.1.1 below, and have been assessed based on an overall rail corridor width of 16.5 m as per the geometric clearance arrangement outlined in the typical cross-section shown in Figure 21.

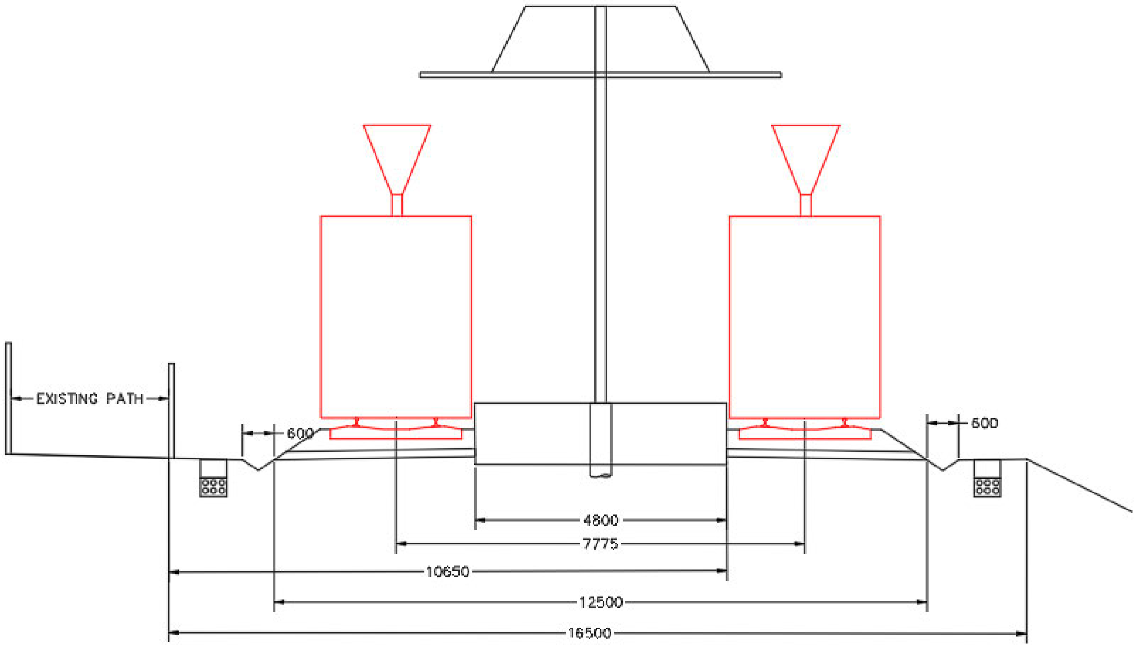


Figure 21 Typical Cross-Section for Platform and Passing Loop Arrangement

Where the existing rail corridor width is not sufficient to accommodate both the station and passing loop arrangement highlighted above, dual tracks or only track passing loop arrangements have been assessed based on an overall rail corridor width of 12 m as per the geometric clearance arrangement, outlined in the typical cross-section shown in Figure 22.

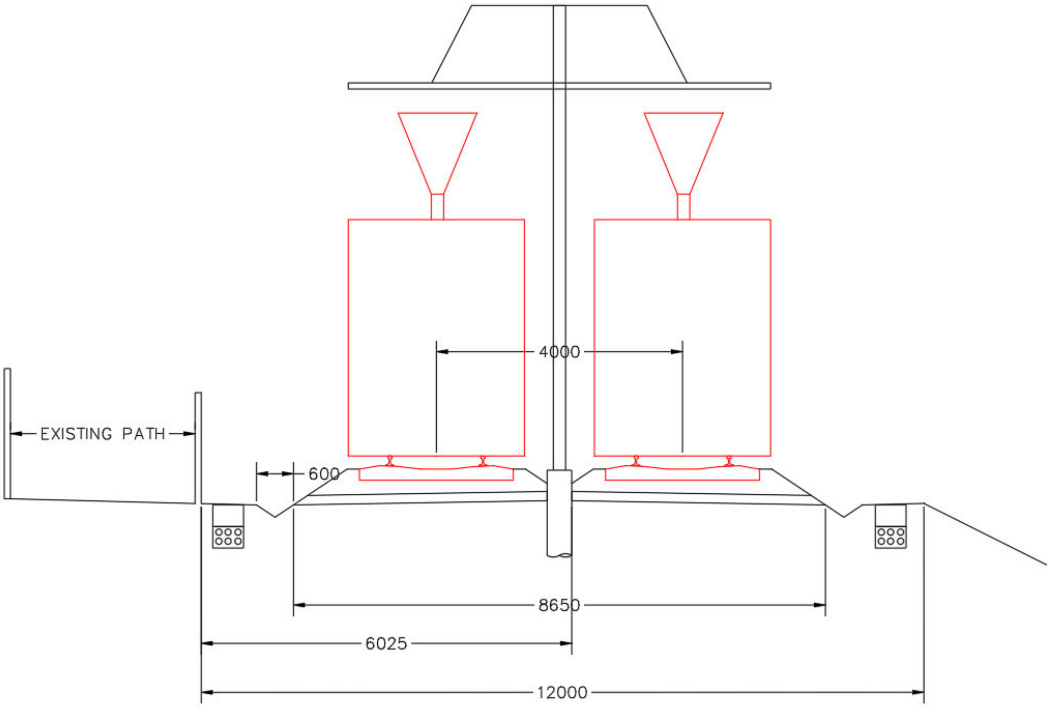


Figure 22 Typical Cross-Section for Passing Loop Arrangement

Passing loop locations have been identified based on the outcomes of a high-level desktop travel analysis (timetable production), which was undertaken based on a 10-minute headway to inform the indicative travel time for both the outbound and inbound services between Macquarie Point and Glenorchy Central stations. Time vs Distance graphs were derived from the timetable modelling data and were used to determine the possible passing loop locations.

Further work with the Department is needed to determine the desired frequency of future transit services and this frequency may change the passing loop locations and lengths presented below. If insufficient corridor widening and passing loop works are undertaken initially, this can severely limit the ability of the corridor to provide more frequent transit services in the future.

Table 14 Locations of Passing Loops

Passing Loop ID	Approx. passing loop chainage (m)	Length (m)	Notes / Comments
1	5520 – 6625 (Approx. between Albert Road and Derwent Park Road)	1105	Reasonable length of track for a passing loop. However, there are multiple road crossings through this chainage range which would require upgrades to account for dual tracks. There is sufficient available space for track duplication east of the existing track, subject to further verification in terms of impacts to existing grassed area. Based on survey data, existing underground services are present which may require relocation as a result of the track duplication, e.g. electrical poles, rail control boxes.
2	1800 – 2130 (Near Royal Tasmania Botanic Gardens)	330	This area has been selected for the station location, and associated passing loop, due to the need for tangent track and in agreement with the outbound / inbound timetable. Other sections of the city-end of the corridor are relatively narrow and very close to the water and constrained by the Tasman Bridge piers, which makes it difficult to accommodate both the station and dual tracks. It should be noted, however, that modifications of existing infrastructure will still be required through this section of the corridor. Due to the large difference in vertical gradient between the existing track and the Domain Highway, it is recommended that track duplication be implemented north of the existing tracks. [redacted]

Passing Loop ID	Approx. passing loop chainage (m)	Length (m)	Notes / Comments
			[redacted] Based on survey data, existing underground services are present which would be affected as a result of the track duplication, e.g. electrical poles, water hydrants, cable junction box.

It is important to note that the desktop timetabling exercise that was undertaken to inform the results of the passing loop locations are of a high level, and are subject to the following limitations:

– The analysis is for the section of route between Macquarie Point and Glenorchy Central Stations only.
– Additional deceleration and acceleration required for traffic signals have not been considered.
– Performance data specific to the type of vehicle have not been considered.
– The timetable is dependent on the vertical alignment; this has not been factored into the analysis.
– Buses may be able to travel slightly faster through horizontal curves.

4.1.7.1 BRT station requirements

The Rapid bus transit services required at the station locations identified, based on an overall roadway width of 16.5 m designed to Austroads Guide to Road Design and as per the geometric clearance arrangement outlined in the typical cross-section, are shown in Figure 23.

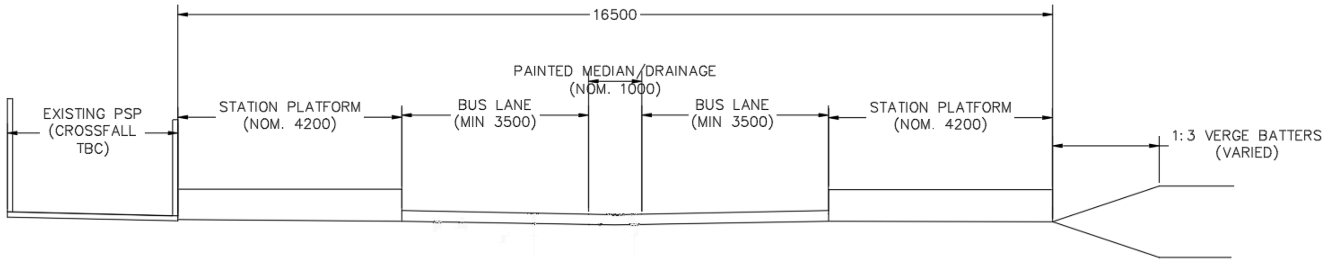


Figure 23 Typical Cross-Section for RBT Station

Due to the constrained nature of the existing corridor, indented bus bays at station locations cannot be achieved. In addition, there is no opportunity to provide passing lane services along the corridor; it is therefore assumed bus services will need to stop at all stations and/or bus stops irrespective of whether passengers are waiting to board at these stations. It is recognised, as with the LRT, that any delays in the outbound and inbound services can potentially result in the poor operation of the overall bus system. Additionally, should a bus break down along the transit route there is no opportunity for buses to pass, thus compromising the operation of the bus network.

4.1.7.2 Travel time

The high-level desktop timetabling exercise indicates the one-way travel time of the transit service is approximately 14 minutes. Noting the limitations of the timetabling, this estimated travel time is not dissimilar to the current car travel time between Macquarie Point and Glenorchy Central. Although the high level timetable modelling indicate that only 2 nominal passing locations are required for a 10 minute headway, this would not allow any flexibility or adjustment required to operate a service beyond the current investigation extents.

It has been indicated that there is likely to be a reduction in headway required. The consequence would be an increased number of passing locations within a corridor that is already highly constrained for width. This would result in an increased travel time, and lower operational reliability of the transit services if the dedicated track / lane is not provided in each direction. This is due to the fact that if one service is delayed, it will have a greater flow-on effect for other services on the line, with vehicles unable to pass each other until the delayed vehicle has passed. As such, the transit system may no longer be competitive with other modes of transport. Therefore, it is important to consider the extent to which the existing corridor should be widened, the overall cost considerations, its impacts to the operability of the transit system and any intention of future extensions and reduction in headways.

4.1.8 Rail civil infrastructure

4.1.8.1 Earthworks

Following analysis of the survey data, aerial imagery and 360º drone video footage, there are multiple locations where steep embankments of generally 1(H):2(V) grade are located within proximity to the existing track, with various densities of vegetation observed along the alignment. These steep embankments generally occur between Macquarie Point Station and New Town Station where the bay is located adjacent to the rail corridor; however, there are other various locations where steep embankments have been identified, including on the approach to and departure from rail and road bridges.

Various degrees of clearing, grubbing and general topsoil removal will be required below the corridor footprint, with major earthworks including bulk cutting and fill as required to widen the rail corridor and achieve the finished sub-ballast and subgrade levels in accordance with Tasmanian Railway Standard Document TR-INF-STD-027 as noted in Figure 24.

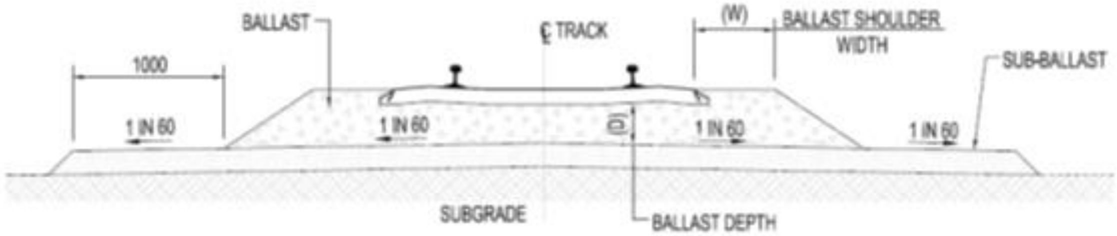


Figure 24 Track Formation (Extract From TR-INF-STD-027)

Due to the proximity of the steep embankments, retaining walls may be required along the alignment to accommodate the widening of the rail corridor, additionally it is recommended a slope stability and geotechnical assessment be undertaken to determine whether the existing ground conditions can support an active light rail system.

4.1.8.2 Combined Service Route (CSR)

Limited information regarding location and condition of any existing combined service route assets have been provided within the survey data or Dial Before You Dig (DBYD), therefore it has been assumed a new CSR and supporting infrastructure including but not limited to in-ground pit and pipe containment, under rail crossings and tertiary service routes will be required to service track side infrastructure, signalling infrastructure, electrical infrastructure (e.g. battery charging points), passing loop infrastructure and potential station and rail crossings facilities.

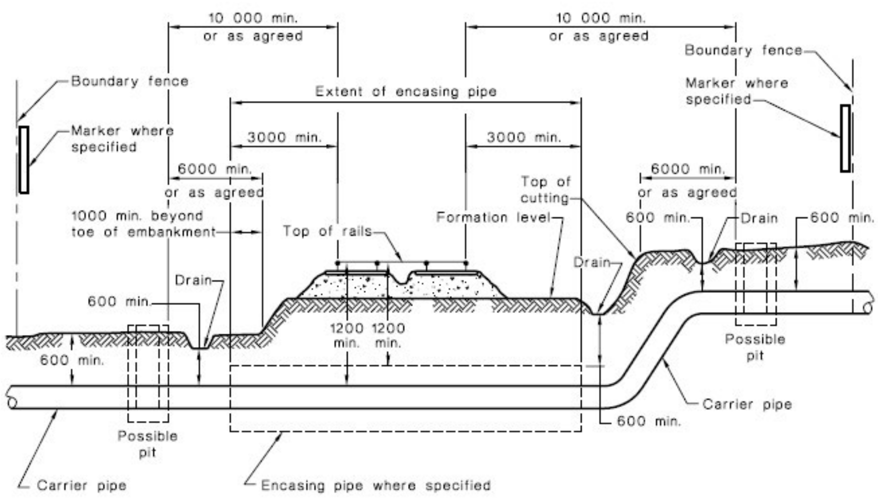
The CSR has been spatially considered within the overall rail corridor footprint for the purposes of this high-level assessment, however, subject to further design development, additional features currently not identified may be required.

4.1.8.3 Drainage

Limited information regarding existing drainage infrastructure located within the rail corridor has been provided within the survey data or Dial Before You Dig (DBYD), therefore it has been assumed new drainage infrastructure will be required within the rail corridor.

An open drainage system has been spatially considered within the overall rail corridor footprint for the purpose of this high level assessment; however, subject to further design development, additional features currently not identified may be required.

Limited existing drainage pipe crossings located under the rail identified within the provided survey data, have been assessed to ensure they comply with the minimum cover requirements outlined within Australian Standards AS 4799-2000. All identified under-track drainage infrastructure currently complies with the minimum 1.2 m cover from existing track level as shown in Figure 25.



DIMENSIONS IN MILLIMETRES
(HORIZONTAL DIMENSIONS MEASURED AT RIGHT ANGLES TO TRACK)

FIGURE 4.1 TYPICAL SECTION OF PIPELINE CARRYING NON-FLAMMABLE SUBSTANCES UNDER TRACKS

Figure 25 Minimum Cover Requirements for Non-flammable Infrastructure (extract for AS 4799-2000)

4.1.8.4 Fencing and lighting

Following an analysis of the survey data, aerial imagery and 360º drone video footage provided it appears no existing lighting is provided along the rail corridor, however existing lighting is provided to support the function of the adjacent shared path. Further investigation and data on the existing lighting conditions are required to determine if the existing luminance is sufficient or can be upgraded to meet the minimum lighting requirements of the rail corridor.

For this assessment it is envisaged that the existing lighting will not be adequate for the LRT / BRT, particularly when considering maintenance activities post construction. Additional lighting will likely be required along the full length of the alignment.

There is an existing pedestrian guardrail fencing, assumed to be 1.4 m high, between the rail corridor and adjacent shared path. It is recommended that this fence be upgraded to current design standards to provide the required level of separation and safety between cycle path users and the LRT / BRT services.

Additional fencing and/or gates may be required at the following locations:

– Additional security fencing where required to restrict public and unauthorised access to the rail corridor
– Where required to provide separation to hazards located within the rail corridor (e.g. bridge piers)
– Where required to protect pedestrian and maintenance workers from steep batters, vertical falls and other hazards identified within the rail corridor
– At pedestrian rail crossings to safely direct pedestrian movement through the rail corridor in accordance with the Disability Discrimination Act (DDA) and Australian Standards

Noisewall and screenwalls have been excluded from this assessment, however, it is noted that noisewall and screenwall infrastructure may be required through areas of the rail corridor subject to the outcomes of an visibility intrusion analysis and noise assessment.

4.1.8.5 Road and pedestrian crossings

Limited road and pedestrian signalling infrastructure have been identified with no existing boom barrier arrangements identified along the length of the rail alignment. It is envisaged that active protection boom barriers and flashing signals will not be required for the transit service. Generally, modern LRT or BRT systems operating under line-of-sight at speeds up to 80 km/h can be managed by traffic signals at road intersections, in lieu of boom barriers and flashing lights. Given the lack of similar transit systems around Hobart city, members of public in Hobart may not be familiar with the new arrangement. As such, a higher level of protection than standard traffic signals (i.e. protective boom barriers, audible bells and sirens, flashing signals) could be considered in accordance with Australian Standards 1742.7. However, higher level of active protection would lead to higher capital expenditure and potentially greater maintenance costs (more equipment to be maintained). It is recommended that a risk assessment be undertaken in later stages of the project, to determine the level of protection appropriate for the transit route. The impacts of traffic signals or higher levels of protection on the existing road network will also be subject to traffic analysis in future stages of the project.

For the existing pedestrian rail crossings, it is recommended that these are upgraded to pedestrian operated signals including a maze approach equipped with , alarms, tactile ground indicators and visual displays, all of which are activated to alert pedestrians of an approaching tram or bus. However, similar to the road crossings, it is recommended that a risk assessment be undertaken in later stages of the project, to determine the level of protection appropriate for the transit route. Additionally, all pedestrian crossings shall be upgraded to comply with the current DDA requirements including maximum path / ramp dimensions and grades, in addition to minimising flangeway gaps for light rail

Depending on the final station locations, new pedestrian crossings may be required to provide improved pedestrian connectivity to new station platform and overall rail services. The detailed locations of new crossings are subject to further development of the proposed transit route.

Subject to the final passing loop locations, some of the existing crossings may also need to be reconfigured to accommodate dual tracks, this includes both road and pedestrian crossings. A high-level review of the existing crossing locations was undertaken using the aerial imagery and found that removing existing crossings would be difficult to achieve, where only two pedestrian crossings were not considered to be essential. Many of the existing road and pedestrian crossings are the only means of access or connection between the two sides of the rail corridor, which did not appear to have any alternative access arrangements if they were removed.

There is also a high risk of trespass if these existing crossings are blocked off. It is critical that pedestrian control is provided at set locations along the transit route, such that illegal or unexpected crossings are reduced as much as possible. This also allows tram or bus drivers to understand where along the route they may expect the presence of pedestrians.

4.2 Structures

4.2.1 Risdon Road Rail Bridge condition assessment recommendations

Methods of repair and maintenance have been suggested in accordance with VicRoads Bridge Maintenance and Repair Manual. Table 15 details the list of defects and the recommended actions.

Table 15 Recommendations

Defect	Recommended Method	Location	Quantities	Comment
Repair Items				
Corrosion	Preliminary lead testing to be undertaken. Any lead paint removal to be performed by specialist contractor with PCCP Classification 5 and in accordance with AS4361. Abrasive blasting to remove corrosion and remaining paint. Repaint surface with primer and coating.	Deck soffit edges where flashing installed, isolated patches on deck soffit, and landing plates at soffit/bay wall interface.	15 m^2	At the time of repairs, consider removing steel flashing and performing a Level 3 Bridge Inspection. To extend the design life of the wrought iron members, repaint members following corrosion removal.
Maintenance Items				
Abutment joint failure	Replace the abutment joints to prevent water ingress to substructure. Maintenance Method M11 recommended.	Both abutment joints	10 m	
Debris and build-up on bearing plates	Debris and build-up should be cleared for all bearing plates and abutments. Maintenance Methods M04 and M05 recommended.	All bearing plates and abutment shelves.	8 no.	It is recommended that this be implemented in a regular maintenance schedule.
Deck soffit calcium build-up	Clean horizontal surfaces by scraping or brushing. Flush with pressurized water to remove salt, dirt, and debris. Dirt material should be collected and disposed of at an approved disposal site. Lead testing is required prior to cleaning, as per Corrosion repair.	Central deck soffit, and isolated areas of build-up on south-western segment.	50 m^2	This should be implemented in a regular maintenance schedule to prevent further damage to wrought iron members.
Deck soffit calcium build-up (Optional)	In addition to removing calcium build-up, consider excavating deck fill and re-sealing cracks in above concrete to inhibit water ingress and deterioration of	Entire deck surface	120 m^2	Removal of the calcium build-up is recommended. This repair type is optional.

Defect	Recommended Method	Location	Quantities	Comment
	deck soffit. This will prevent recurrence of calcium build-up.			
Concrete cracks and delamination	Repair cracks using epoxy injected at sites on either side of crack. Patch repairs of concrete where spalling and delamination have occurred.	Large crack at interface between wingwall and wingwall return, horizontal cracking at capping beam junction on the Abutment 2 Wingwall 2, and interface between Abutment 1 and Wingwall 2	4 m^2	No action should be taking where minor cracking with autogenous healing is observed. These cracks are believed to have self-healed.
Missing, loose, or severely corroded rivets	Defective rivets should be removed by cutting out. If plates are misaligned, ream existing holes to permit insertion of new bolt. Replace with high strength grade 8.8 friction grip bolts.	Defective rivets located on Girders 1 and 2, and Horizontal-Bracing 1.	4 no.	
Further Investigation				
Steel flashing on deck soffit	Steel flashing should be removed for further investigation into the extent of corrosion to deck soffit. This may be included in a Level 3 Bridge Assessment.	Edges of deck soffit.	40 m	This should be carried out in conjunction with corrosion repairs, such that any corrosion can be removed from soffit edges.
Interface between soffit and bay wall	Undertake a Level 3 Bridge Assessment to inspect the extent of corrosion and deflection. Replace end members if required.	Interface between deck soffit and bay wall where end members have deflected.	5.5 m	This should be carried out in conjunction with corrosion repairs, such that any corrosion can be removed from soffit edges.

4.2.2 New Town Rivulet Bridge condition assessment recommendations

Methods of repair and maintenance have been suggested in accordance with VicRoads Bridge Maintenance and Repair Manual. Table 16 details the list of defects and the recommended actions

Table 16 New Town Rivulet Bridge Recommendations

Defect	Recommended Method	Location	Quantities	Comment
Repair Items				
Sandstone mortar cracking	Repointing of the stonework is recommended where the depth of the mortar loss reaches 20 mm. A repair methodology has been developed for the repointing works during the 2018 repairs. It’s recommended that repairs are undertaken in accordance with this methodology.	Sandstone sections of Abutment 1 & 2.	30 m^2	
Maintenance Items				
Deteriorated timber sleeper utilised at the retaining wall	Replace the damaged timber sleepers utilised for the timber retaining wall.	Retaining wall on the eastern end of the north bank.	4 m	
Debris and build-up on bearing plates	Debris and build-up should be cleared for all bearing plates and abutments. Maintenance Methods M04 and M05 recommended.	All bearing plates and abutment shelves.	12 no.	It is recommended that this be implemented in a regular maintenance schedule.
Missing, loose, or severely corroded bolts	Tighten loose bolts. Defective bolts should be removed by cutting out. If plates are misaligned, ream existing holes to permit insertion of new bolt. Replace with high strength grade 8.8 friction grip bolts.	Bearings at Abutments 1 & 2. Bolts connecting the girders to the deck.	50 no.	
Pedestrian footpath support member corrosion	Preliminary lead testing to be undertaken. Any lead paint removal to be performed by specialist contractor with PCCP Classification 5 and in accordance with AS4361. Abrasive blasting to remove corrosion and remaining paint, repaint surface with primer and coating.	Steel support members of the pedestrian footpath attached to Abutment 1.	10 m	
Further Investigation				
Sandstone abutment bulging and movement within the wingwall	It’s recommended that further detailed engineering investigations are undertaken to determine the stability of the wall. Based on the outcomes of a detailed analysis, a suitable remediation/replacement methodology can be derived.	Sandstone sections of Abutment 2	1 no.	The wall may require replacement depending on the severity of the damage. It’s recommended that further investigations are undertaken by a structural engineer.

4.2.3 Further considerations

The focus of the rail corridor condition assessment has been on the physical condition of the bridge assets. It is important to highlight that there are additional structural considerations along the rail network, including:

- Pier protection from derailed light rail or BRT at structures over rail: and
- Containment of derailed light rail or BRT on bridges.

These protection measures are fundamental to ensuring the safety of those utilising the railway and the continued safe operation of the bridge(s).

To ensure future-proofing the transit corridor we would recommend adopting the most onerous requirement outlined below when considering BRT and LRT requirements.

4.2.3.1 Pier protection

The Australian Standard AS5100.1 Scope and General Principles and AS5100.2 Design Loads outline several requirements with regards to pier protection for light rail networks. These requirements are deemed necessary to ensure that in the event of a light rail train derailment, the structure passing over the railway is protected (or damage sustained is limited).

It is important to note that AS5100 does not differentiate between the collision requirements of a light rail train and that of a much heavy freight style train referred to as the 300LA in AS5100.

In summary, the requirements include:

- Bridges to have a clear span over railway lines. However, where the *Relevant Authority* approves piers between the abutments then:
  - Where the closest face of a pier is within 10 m of the centreline of the railway line then provision for derailment shall be made in the form of pier protection or structural redundancy
  - Where the face of a pier is between 10 m and 20 m from the centreline of the railway line then a risk assessment shall be undertaken to the satisfaction of the *Relevant Authority* to determine the pier protection requirements
- Piers may be designed to be removed in the event of derailment and subsequent impact (i.e. frangible). However, the bridge superstructure shall not collapse in the event of a frangible pier removal and the deformation of the bridge superstructure is within the limits set by the *Relevant Authority*. Rail bridges shall not be supported on frangible piers.
- Where piers are not designed as frangible then both the following requirements shall be met:
  - Deflection walls installed to prevent a head on impact with a bridge pier, where the deflection wall shall:
    - Not impart any load onto the bridge
    - Form a continuous wall
    - Minimum height of 2 m above rail level
    - Minimum thickness of 500 mm
    - Smooth face
    - Rounded approach end
  - Continuous concrete wall aligned parallel to the railway, where the concrete wall shall:
    - Have a minimum height of 3.6 m above rail level where the pier is less than 4 m from the centreline of the railway track; or 2.0 m above rail level where the pier is greater than 4 m from the centreline of the railway track
    - Minimum thickness of 800 mm
    - Minimum length of 4 m
    - Extend a minimum 2 m beyond any column extending above the wall
    - Extend a minimum 1.2 m below ground
    - Extend a minimum 150 mm laterally beyond the face of any column rising above the wall

- Smooth face
- Rounded end(s)

In addition to the above geometric requirements, significant loads both parallel and normal to the railway line are to be resisted by the pier protection arrangement.

It is important to note that the minimum corridor width of 8.5 m for both BRT and LRT does not include the minimum required width of pier protection at bridges. Therefore, where the transit corridor passes below a bridge, the minimum corridor width should be 10.1 m (i.e. 8.5 m corridor + 800 mm (min) each side for pier protection for LRT).

The Australian Standard AS5100.1 Scope and General Principles and AS5100.2 Design Loads remain silent on the pier protection requirements for BRT. At a high level, GHD would anticipate that the requirements for road traffic impacts would dictate the necessary pier protection measures for bridges over rail. There are strong similarities between BRT vehicle mass and the operating speed to buses and trucks covered by AS5100 road traffic requirements.

On this basis, the requirements include:

- The *Relevant Authority* shall determine the minimum clearance from the centreline of railway to the bridge supporting element to which protection shall be provided.
- Based on experience GHD understand that State Growth may require:
  - Rigid Barrier immediately in front of the pier
  - Flexible barrier (three beam or similar) with suitable deflection distance in front of the pier

In addition to the above geometric requirements, significant loads both parallel and normal to the railway line are to be resisted by the pier protection arrangement.

These pier protection requirements are likely to impact the following structures. We note that these bridges should be designed for the worst case of BRT and Light rail requirements:

- Tower Road Bridge;
- Bellevue Parade Underpass (Brooker Highway Overpass); and
- Tasman Bridge.

4.2.3.2 Bridge barriers

The Australian Standard AS5100.1 Scope and General Principles and AS5100.2 Design Loads remains silent on the barrier requirements for BRT. At a high level, GHD would anticipate that the requirements for road bridges would dictate the necessary barrier requirements for BRT. There are strong similarities between BRT vehicle mass and the operating speed to buses and trucks covered by AS5100 road traffic requirements.

It is commonly understood that it can be extremely challenging to retrofit appropriately designed barriers onto existing older bridges.

These barrier requirements are likely to impact the following structures. We note that these bridges should be designed for the worst case of BRT and Light rail requirements:

- Risdon Road Rail Bridge; and
- New Town Rivulet Bridge.

4.2.3.3 Proximity of corridor structures

Throughout the length of the corridor there are several structures such as industrial buildings, residential dwellings, schools and similar. Consideration should be provided to risk assess and provide an appropriate level of protection as deemed necessary.

4.2.4 Bridge recommendations

The condition of both the Risdon Road Rail Bridge and New Town Rivulet Bridge was found to be reasonable given their age and exposure environment, however:

– Both bridge deck width(s) were found to be insufficient to accommodate the required corridor width for either BRT or LRT;
– To enable the corridor to be used for BRT or LRT then bridge barriers will be required along each edge of the bridge deck;
– Each bridge should be designed for the most onerous requirements for BRT and LRT to ensure the corridor is not constrained to one mode of transit.
– The age of Risdon Road Rail Bridge is more than 100 years, and New Town Rivulet is likely to be similar. Bridges designed to current standards can expect a service life of at least 100 years, however the principle of service life was likely not well understood at the time the original design. Following any strengthening or widening works to these existing bridges, the asset will still be more than 100 years old, and serving a newly refurbished transit corridor.

While the defects encountered during the condition assessment for both the Risdon Road Rail Bridge and New Town Rivulet Bridge are anticipated to be relatively easily remediated; the further considerations outlined above relating to bridge width and barriers are likely to require extensive (costly) strengthening works and bridge widening to the existing structure(s). On this basis we would recommend replacing both Risdon Road Rail Bridge and New Town Rivulet Bridge in lieu of remediation, widening and strengthening as the more practical solution.

The condition of Tower Road Bridge, Bellevue Parade Underpass and Tasman Bridge was not assessed as part of this project, however because of pier protection requirements, we note that:

– Bellevue Parade Underpass abutments and piers are within the 10 m zone from centreline of rail; therefore pier protection requirements shall be met. It is understood the width of the corridor between the abutment and piers is restrictive and does not meet the minimum width requirements (even when not considering pier protection measures). It is understood that this bridge will be replaced in 2 – 6 years as part of the Brooker Highway / Domain Interchange upgrades due to strength deficiencies and limited deck width to accommodate three lanes along the Brooker Highway in each direction.

  The replacement bridge shall consider the requirements for rail impact/pier protection or be designed for structural redundancy.
– Tower Road Bridge abutments and piers are within the 10 m zone from centreline of rail; therefore pier protection requirements shall be met. It is understood the width of the corridor between piers is restrictive and does not meet the minimum width requirements (even when not considering pier protection measures).

  A replacement bridge at this location is likely to be required unless a reduction in corridor width can be achieved as well as the adjacent intercity cycleway relocated from its current location.
– Tasman Bridge piers are within the 10 m zone from centreline of rail; therefore pier protection requirements shall be met. It is understood the width of the corridor between the piers is restrictive and does not meet the minimum width requirements. Given the size and of this bridge replacement is not considered appropriate and therefore assessment of the impacts to the bridge from the corridor network will be required.

4.3 Services

4.3.1 Authorities consulted

The following service authorities were contacted to understand any issues and future plans for their assets along the corridor:

– Optus
– NBN
– TasmaNet
– TPG Networks
– TasNetworks
– TasWater
– City of Hobart
– Glenorchy City Council

– DPIPWE
– TasGas

4.3.2 Existing infrastructure

A Dial Before You Dig (DBYD) request was submitted to confirm the existing utility information. This will need to be confirmed against the detailed survey. Information from available GIS information from TasWater, Glenorchy Council, and City of Hobart were used to assess the existing utilities on site. The information is summarised in Table 17 below.

Table 17 Existing utilities in or near the project area

Utility	Organisation	Utility in/near area	Comments
Telecommunications	Optus	Yes	Indicated cables along the rail corridor
	NBN	Yes	Indicated cables along the rail corridor
	TasmaNet	Yes	Indicated cables along the rail corridor
	TPG Networks	Yes	Indicated cables along the rail corridor
	TasNetworks	Yes	Indicated cables along the rail corridor
Water	TasWater	Yes	Indicated water assets along the rail corridor
Sewer	TasWater	Yes	Indicated sewer assets along the rail corridor
Stormwater	City of Hobart	Yes	Indicated stormwater assets along the rail corridor
	Glenorchy City Council	Yes	Indicated stormwater assets along the rail corridor
Electricity	TasNetworks	Yes	Indicated low voltage cables and high voltage cables along the rail corridor
Heritage	DPIPWE	Yes	Aboriginal relics along the rail corridor
Gas	TasGas	Yes	Indicated medium high pressure, medium high pressure (strategic), high pressure pipes, and customer services along the rail corridor
	Glenorchy City Council		Indicated presence of old town gas along the rail corridor
Traffic signals	Department of State Growth	None	-

4.3.3 NBN

Dial Before You Dig (DBYD) plans indicate the NBN cables run:

– Between Peltro Street and Lampton Avenue, along the western side of the Intercity Cycleway, crossing the existing rail corridor near Elwick Road.
– Between Howard Road and Lampton Avenue, along the eastern side of the existing rail corridor

DBYD plans indicate NBN cables cross the existing rail corridor near:

– 9A Lampton Avenue
– Derwent Park Road/Springfield Avenue
– 7 Gatehouse Street
– Tower Road
– Risdon Road
– Bay Road

4.3.4 Optus

DBYD plans indicate Optus cables run along the northern side of the existing rail corridor, between Risdon Road and Oldham Avenue.

DBYD plans indicated Optus cables cross the existing rail corridor:

- Eady Street
- Farley Street
- Derwent Park Road
- Risdon Road

4.3.5 TasmaNet

DBYD plans indicate a TasmaNet conduit travels along Hopkins Street, crossing the existing rail corridor.

4.3.6 Tas Gas

A summary of the TasGas assets, as indicated on the DBYD plans, has been provided in Table 18 below.

Table 18 TasGas Assets

Pipe	Location
High pressure steel	DBYD plans indicate high pressure steel gas pipes: – Run along the eastern side of the existing rail corridor between Howard Road and Lampton Avenue – Run east of the existing rail corridor, between Lampton Avenue and Linear Court – Run along the western side of the Intercity Cycleway, between Linear Court and Derwent Park Road – Run along the eastern side of the existing rail corridor, between Derwent Park Road and Brownells Lane – Cross the existing rail corridor near: • Linear Court • Derwent Park Road • Brownells Lane
Medium pressure (strategic)	DBYD plans indicate medium pressure (strategic) gas pipes: – Run to the east of the existing rail corridor between Lampton Avenue and Linear Court – Run along western side of Intercity Cycleway between Linear Court and Derwent Park Road – Run along eastern side of the existing rail corridor between Derwent Park Road and Brownells Lane – Cross the existing rail corridor near: • Lampton Avenue • Linear Court • Derwent Park Road • Brownells Lane • Hopkins Street • Albert Road

Pipe	Location
Medium pressure	DBYD plans indicate medium pressure gas pipes: – Run to the east of the existing rail corridor between Howard Road and Lampton Avenue – Cross the existing rail corridor near: • Elwick Road • Tower Road • Risdon Road • Bay Road

Information regarding old gas pipelines was obtained online from the *TasWater Asset Information Portal*[1]. Old town (abandoned) gas lines cross the existing rail corridor near:

- Elwick Road
- Derwent Park Road
- Hopkins Street
- Albert Road

4.3.7 TasNetworks

DBYD plans indicate TasNetworks assets can be found along the existing rail corridor. This includes Distribution High Voltage (HV) and Low Voltage (LV) cables. These assets may be located underground or overhead.

4.3.7.1 Low Voltage

DBYD plans indicate low voltage cables run:

- Along the western side of the Intercity Cycleway, between Peltro Street and Bay Road.
- Parallel to the rail corridor (for approximately 100 m), near the Brooker Highway junction.
- Along the western side of the Intercity Cycleway, near Lower Domain Road junction for approximately 400 m.

The plans also indicate low voltage cables cross the existing rail corridor, in nine locations (refer Table 19).

4.3.7.2 High Voltage

DBYD plans indicate high voltage cables run:

- Along the eastern side of the existing rail corridor, between Peronne Avenue and Hamel Street
- East of the existing rail corridor between Bay Road and Bishop Street
- Along the western side of the Intercity Cycleway between Queens Walk and McVilly Drive.

The plans also indicate high voltage cables cross the existing rail corridor, in 17 locations (refer Table 19).

4.3.7.3 Fibre optic cables

DBYD plans indicate TasNetworks fibre optic cables run along the:

- Eastern side of the existing rail corridor between Howard Road and the Zinc Works Rail Line.
- Western side of the Intercity Cycleway between the Zinc Works Rail Line and Derwent Park Road.
- Eastern side of the existing rail corridor between Derwent Park Road and Hamel Street.

DBYD plans indicate fibre optic cables cross the existing rail corridor, in five locations (refer Table 19).

[1] TasWater, TasWater Asset Information Portal, *https://taswater.maps.arcgis.com/apps/webappviewer/index.html?id=8a46c12587ed40afa3360f76271d48b7*, accessed 17 September 2021.

4.3.7.4 Lighting

Lighting is provided near to the existing rail corridor, along the Intercity Cycleway. Lighting is provided predominately on the western side of the shared path.

4.3.7.5 Crossings

DBYD plans indicate TasNetworks assets cross the existing rail corridor, in approximately 31 locations. These have been described in the table below.

Table 19 TasNetworks Crossings

Indicative Crossing Location	LV Cables	HV Cables	Fibre Optic Cables
Peltro Street	✓✓	✗	✗
Elwick Road	✓✓✓	✓	✗
5 Esmond Street	✓	✓	✗
Lampton Avenue	✗	✓✓✓✓	✓
Zinc Works Rail Line	✗		✓
Howard Road/Derwent Park Road	✓	✓	✓✓
Opposite 8 Birdwood Avenue	✓	✓	✗
Hopkins Street	✗	✓	✗
Albert Road	✗	✓	✗
Peronne Avenue	✗	✓	✗
Bromby Street (	✓	✓	✗
Tower Road	✗	✓✓	✗
Bishop Street	✗	✓✓	✗
Brooker Highway	✗	✗	✓
Queens Walk	✗	✓	✗

The number of ticks provided in the table above, indicates the number of cables crossing the existing rail corridor, as shown on the DBYD plans.

4.3.8 TPG Telecom

DBYD plans indicate that underground telecommunication (TPG) cables run along the western side of InterCity Cycleway between Howard Road and Lampton Avenue.

The plans also indicate a cable crosses the existing rail corridor, near Elwick Road.

4.3.9 TasWater

TasWater information was sourced from the online from the *TasWater Asset Information Portal*[2] and has been summarised below.

[2] TasWater, TasWater Asset Information Portal, *https://taswater.maps.arcgis.com/apps/webappviewer/index.html?id=8a46c12587ed40afa3360f76271d48b7*, accessed 17 September 2021.

4.3.9.1 Sewer

TasWater's online spatial database indicates sewer main pipes run predominately outside of the State Rail Network but cross the existing rail corridor in several locations. This includes near:

– 8 Constance Avenue
– Lampton Avenue
– Derwent Park Road (two sewer main pipes)
– Sunderland Street
– Queens Walk (three sewer main pipes, including a pressurised pipe)

4.3.9.2 Water

TasWater's online spatial database indicates water main pipes run predominately outside of the State Rail Network.

The database indicates a water main pipe travels along the existing rail corridor, between the Botanical Gardens car park and Derwent Mercantile Collegiate Boatshed.

The database also indicates there are several locations where a water main crosses the existing rail corridor. This includes near:

– Howard Road
– Lampton Avenue
– Derwent Park Road
– Sunderland Street
– Albert Road
– Tower Road
– Risdon Road (two water main pipes)
– Bay Road
– Queens Walk (two water main pipes)
– Botanical Gardens Car Park
– McVilly Drive

4.3.10 Telstra

The DBYD plans indicate Telstra cables run within the existing State Rail Network, for the length of the existing rail corridor.

DBYD plans indicate Telstra cables cross the existing rail corridor near:

– Lampton Avenue (multiple crossings)
– Between Lampton Avenue and Linear Court (multiple crossings)
– Linear Court (multiple crossings)
– Zinc works rail line (multiple crossings)
– 10 Derwent Park
– Derwent Park Road (multiple crossings)
– 13 Derwent Park
– 56 Sunderland Street
– Peronne Avenue
– Tower Road (multiple crossings)
– Risdon Road (multiple crossings)
– Bay Road (multiple crossings)

– Tasmanian Hockey Centre (multiple crossings)

4.3.11 DPIPWE

The DBYD enquiry indicated there may be Aboriginal relics or risk of impacting Aboriginal relics, if excavation works were to be undertaken within the existing rail corridor.

4.3.12 Aboriginal Heritage desktop review

An Aboriginal Heritage Desktop Review was conducted by the Aboriginal Heritage Tasmania, Natural and Cultural Heritage Division of Department of Primary Industries, Parks, Water and Environment (DPIPWE).

> *Aboriginal Heritage Tasmania (AHT) has completed a search of the Aboriginal Heritage Register regarding the proposed Northern Suburbs Transit Corridor development and can advise that there is registered Aboriginal heritage present within the corridor. The area around Cornelian Bay and The Domain is rich in Aboriginal heritage and includes dozens of shell midden and artefact sites, including at least 5 sites which have been intersected by the construction of the railway line itself.*
>
> *It is AHT's recommendation therefore that as part of GHD's scoping and assessment of the railway corridor, that an Aboriginal heritage assessment be undertaken to identify whether the proposed project or related infrastructure will impact on Aboriginal heritage and to offer avoidance and mitigation advice. This assessment must be undertaken jointly by a Consulting Archaeologist and Aboriginal Heritage Officer.*

4.3.13 Utility impacts to the proposed transit corridor

Several utilities are present on site as noted in section 4.3.2. Key findings and impacts following the desktop assessment of the existing utilities along the corridor are as follows:

– Levels of the existing utilities will need to be confirmed during preliminary/detailed design to ensure that cover and clearance (horizontal and vertical) requirements are as per utility supplier standards.
– Existing utilities may need to be realigned/relocated to suit new track alignment.
– Extent of work will be confirmed following DSG’s approval of the proposed rail corridor cross section.
– Cess drains / sub-surface drains are required parallel the track to collect and manage water from the track formation and embankment. This will need to be assessed to ensure that flows are directed towards the existing pits and outlets. The cess drain will need to be of sufficient depth beneath the track ballast and existing surface to ensure flows are directed to the drain and to reduce/prevent water damage to the track support system and earthworks.
– Some sections of the existing shared path will be affected due to existing culverts running from the outer edge of the path towards the outlet on the eastern side of the track.
– Aboriginal heritage assessment will be required to assess location of affected sites.

4.3.14 Consultation and Feedback Report

See Appendix K.

5. Corridor development P50/P90 estimate and Prioritised Work Schedule

Refer separate report – Appendix L.