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Legend

- Viaduct
- Rail Alignment
- Existing Barrier

Rail Noise Level, dB(A) Lmax

- 70 - 73 dB(A)
- 73 - 76 dB(A)
- 76 - 79 dB(A)
- 79 - 82 dB(A)
- 82 - 85 dB(A)
- >85 dB(A)

Flinders Link Project

30% Design
Noise Assessment
2019 Maximum Rail Noise Levels
Curve Squeal Mitigation

Drawn by:	NH
Checked by:	DJ
Issue date:	December 2017
Revision:	1
Page size:	3276 mm x 841 mm

FIGURE

C8

8

Resonate

Flinders Link - Detailed Design

Curve Squeal Risk and Mitigation Measures

A17715RP1 Revision B

Thursday, 19 April 18

Resonate

Document Information

Project	Flinders Link - Detailed Design
Client	Jacobs Group Australia Pty Ltd
Report title	Curve Squeal Risk and Mitigation Measures
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Revision Table

Report revision	Date	Comments
A	19 December 2017	First Issue
B	20 April 2018	Revised

Table of Contents

1 Introduction

The proposed Flinders Link Project contains a tight curve (radius less than 250m) on an elevated rail structure, in close proximity to residential and other noise sensitive receivers. The 15% Design Noise Assessment Report (issued 4 November 2016) applied an indicative correction factor of 16 dB to predicted LAmax noise levels to account for potential curve/wheel squeal, which resulted in the predicted levels exceeding recommended criteria by up to 6 dB. It was therefore recommended that further research be undertaken to allow for greater certainty of predicted noise levels.

This report documents a review of relevant literature in relation to curve squeal and potential mitigation measures. Measurements or detailed modelling of the proposed rail profile and rolling stock (A-City Class 4000 EMUs) specific to the Flinders Link project have not been undertaken at this stage. We note that pre-construction measurements of curve squeal noise from Class 4000 EMUs is not likely to be possible since no comparable curve radius exists on relevant South Australian sections of track. However, the magnitude of curve squeal and possible benefit of various mitigation measures can be estimated based on experience elsewhere, including New South Wales.

The overall 30% Design Noise Assessment Report is documented separately.

2 Curve Squeal Description

Curve squeal (sometimes referred to as wheel squeal) is a distinctive tonal noise emitted when some rail vehicles negotiate a tight curve (generally less that 500m radius). For vehicles with rigid bogies and parallel, non-steerable axles, lateral slip, or creep, occurs between the wheel and rail. The so-called "stick-slip" mechanism can cause the wheel to oscillate and radiate squeal noise (Rudd, 1976). This is generally considered to be the dominant mechanism although in some cases rail vibration may also contribute to curve squeal (Hanson, Jiang, Dowdell, & Dwight, 2014).

The level of curve squeal can be influenced by curve radius, bogie and wheel design, wheel surface profile and wear, train speed, friction coefficient between the track and wheel, rail profile and wear, track mobility/dynamics, and meteorological conditions. Due to the complex mechanism and large number of variables, the occurrence and magnitude of curve squeal is difficult to predict compared to other rail noise sources.

Curve squeal noise is generally mono-tonal at a frequency between 1500 and 6000 Hz. It is different to multi-tonal "flanging" noise generated by contact between the wheel flange and rail.

Measurements taken at a 284 m radius curve at Beecroft, NSW, indicate that maximum noise levels from passenger train movements are between 6 and 15 dB higher than noise levels from the same trains on straight track sections (TfNSW, 2012).

3 Mitigation Measures

Mitigation measures which could potentially be taken to reduce curve squeal noise can be broadly categorised as follows:

- Friction modifiers and lubrication devices
  - Track-mounted
  - Vehicle mounted
- Rail head modification
- Gauge widening or narrowing
- Rail dampers
- Rolling stock measures
  - Wheel dampers
  - Bogie design / modification
- Noise barriers
  - Low-close barriers
  - General noise barriers
- Speed adjustments

The likely effectiveness and cost of each measure is summarised below, based on Australian and international experience and theoretical research.

3.1 Friction modifiers

The purpose of friction modifiers and lubrication devices is to reduce friction and lateral forces at the wheel/rail interface and therefore interrupt the “stick-slip” mechanism resulting in curve squeal. We note that the primary goal of these product is often reduction of wear and corrugation in curves, with noise reduction being a secondary benefit. Care should be taken to ensure that the friction coefficient does not become too low such that traction and braking performance is compromised.

Systems can be either track-mounted or vehicle-mounted (either on rolling stock or on maintenance vehicles). It is understood that some Class 4000 rolling stock are fitted with vehicle mounted lubrication systems, and scheduled such that all sections of track are lubricated on a regular basis. However, we note that the effectiveness of this system for curve squeal noise mitigation is not known, as there are no existing tight radius curves on the electrified Adelaide network.

Should this system prove to be ineffective in mitigating curve squeal noise to an acceptable level, a track-based system could be considered. These systems are reported to have greatly improved in reliability in recent years and have significantly reduced curve squeal noise in many cases, including several locations in NSW (Hanson, Jiang, Dowdell, & Dwight, 2014).

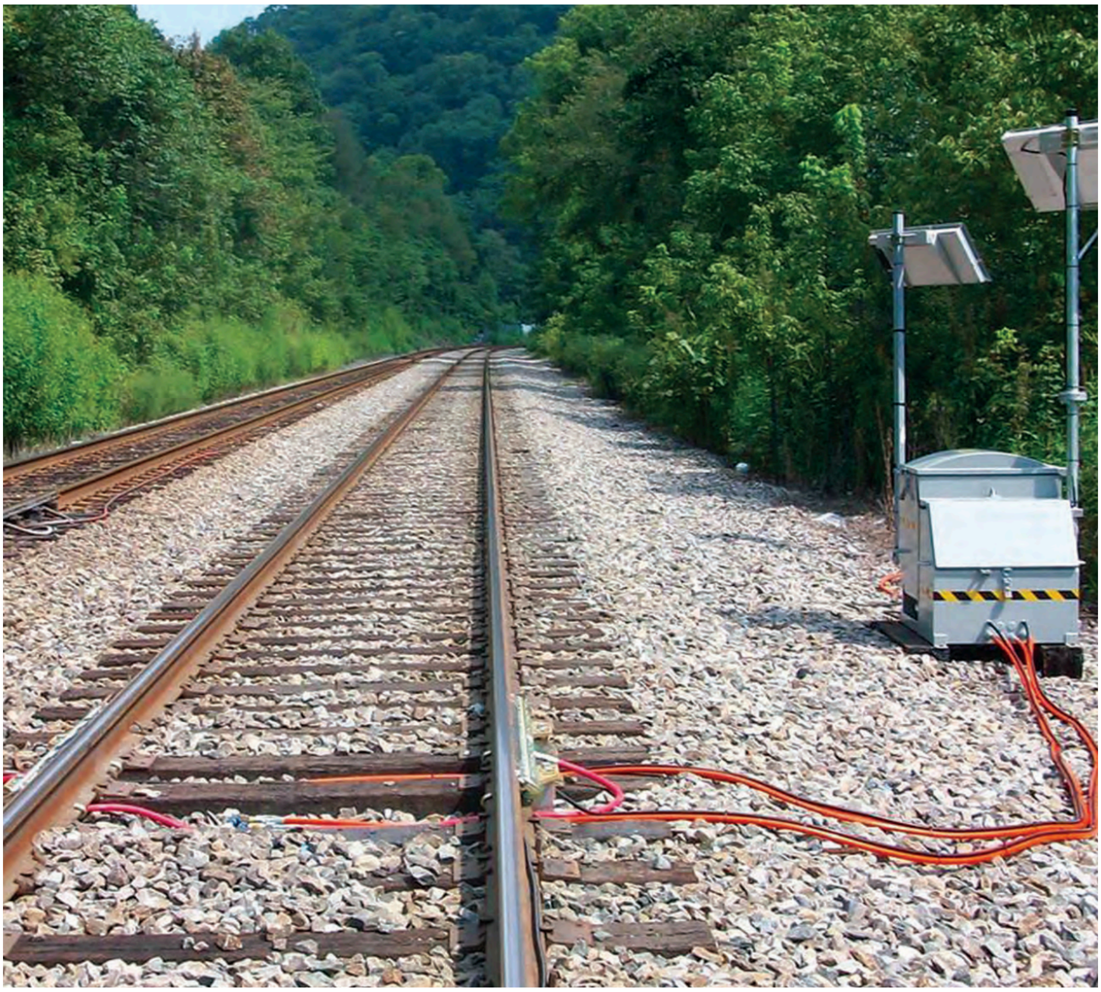

Figure 1 Example of track-mounted friction modification system (LB Foster Rail Technologies).

3.2 Rail head modification

Asymmetrical rail head profiles or impregnation of the top of the rail head with hardened materials have been proposed as potential mitigation measures for curve squeal at some sites. Whilst these measures have proven to reduce the number or squeal events and noise level of each event (by 4 dB on average), the wear rate of the test rail was reported to not meet the required standard. Furthermore, the metal particle impregnation was found to require replacement every five years (Hiensch, 2007).

Based on the above we do not consider this mitigation measure to be appropriate for this application.

3.3 Gauge modification

Widening or narrowing the rail gauge by a few millimetres has been proposed as a potential mitigation measure for curve squeal noise at other locations, including in NSW (Hanson, Jiang, Dowdell, & Dwight, 2014). The intent is to shift the contact position of the inside wheel such that the potential for lateral slip is reduced. The success of this measure requires optimising the gauge for the wheel profile of the rolling stock. Because there is no precedent for curve squeal noise from A-City Class 4000 EMUs on the Adelaide network, it is not possible to determine whether any benefit could be gained from modifying the gauge for this project.

Furthermore, we note that resilient rail fasteners installed to mitigate structure borne noise from the viaduct are likely to allow for some lateral movement of the rail, which could negate any benefit from gauge modification on the curve.

3.4 Rail dampers

Rail dampers are devices mounted on the rail web or foot (or sometimes under the foot) to dampen rail vibration which would otherwise result in radiated noise. They are typically used to reduce general rolling noise (particularly on bridges) but may also be effective in controlling curve squeal noise in situations where a significant component is generated by rail movement.

Observations and measurements in NSW found that replacement of timber sleepers with concrete resulted in a significant increase in incidences of curve squeal, indicating that the dynamic characteristics of the rail system is an important factor.

Figure 2 Rail dampers (Schrey & Veit)

Rail dampers will only mitigate the rail-generated component of curve squeal noise, such that if the wheel component is dominant, they are unlikely to be effective without additional measures to mitigate wheel noise. Recent research in Perth (Zoontjens, Welsh, & Croft, 2017) showed that rolling noise reductions of 4 to 8 dB are possible depending on the stiffness of rail supports, with the greatest noise reduction observed where resilient fasteners (Pandrol Vanguard) were used. It should be noted that the Perth Metro rolling stock have relatively small wheels, meaning that the rail contribution tends to dominate the overall rolling noise levels at key frequencies. Modelling results agreed well with measured noise reduction for the cases examined in Perth.

Detailed modelling for Flinders Link can be carried out a later stage to determine the likely contribution of rail noise to overall curve squeal, based on the dynamic properties of wheels and the proposed rail system. We recommend that at this stage allowance is made for installation of rail dampers on sections of track with resilient rail fasteners.

3.5 Rolling stock measures

Rolling stock measures may include wheel dampers, or modification to bogies to improve curving performance.

Similarly to rail dampers, wheel dampers are designed to reduce wheel vibration leading to squeal noise. In practice wheel dampers are generally easier to implement for new rolling stock, rather than retrofitted to an existing fleet, as brakes and other elements can restrict the available space to fit the dampers. Noise reduction results are somewhat mixed, with reported reduction of 5 dB in one study (Dobbie, Reid, & Padgett, 2000). In another location, wheel dampers retrofitted to existing passenger rolling stock resulted in a shift in frequency of the peak squeal tone, but did not reduce noise levels significantly (Humpheson).

In some cases (particularly for freight vehicles), the primary cause of squeal is poor performance of individual vehicles or bogies in negotiating the curve (resulting in a high when angle of attack on the curve), rather than a systematic problem with all vehicles. This could be an issue associated with the design of the bogies for a class of vehicle, or a maintenance problem, specifically ineffective lubrication of the centre bowl restricting the bogie from turning (Anderson, et al., 2008). Passenger vehicles typically have acceptable bogie turning performance when they are well maintained.

3.6 Noise barriers

Noise barriers are a proven measure for reducing rail noise (including curve squeal) in many situations. Barriers are most effective either close to the noise source or receiver, and of sufficient height and length to block line-of-sight to the noise source. We note that in this case due to the elevated rail structure, line-of-sight to some receivers is already broken by the bridge and parapet structure so any additional benefit from noise barriers may be limited in some locations.

Barriers can either be low-close noise barriers, typically less than 2m from the axis of the nearest track and with a height of less than 1.0m; or conventional noise barriers which are usually at least 4m from the track and have a typical height between 1 and 4 metres. With either type of barrier, acoustic absorption can be applied to the inside face to reduce noise reflection, and the barrier top may be modified to mitigate diffraction.

Noise barriers are modelled as part of the 30% Design Noise Assessment.

3.7 Speed adjustments

Research indicates a weak relationship between speed and the presence and level of curve squeal. While a lower speed will reduce general rolling noise, and therefore the overall noise level, we note that a lower speed will also result in a prolonged exposure to noise from each vehicle.

We do not recommend changing the design speed through the curve as a specific noise mitigation measure.

4 Conclusions

There is significant potential for curve squeal noise on a section of proposed new track on the Flinders Link project, where the radius of curvature is less than 250m.

To mitigate curve squeal noise we recommend that a friction modification/lubrication system is used. We note that there is an existing vehicle mounted system for track lubrication on the A-City Class 4000 EMUs. However, the performance of this system for mitigation curve squeal noise on tight radius curves is not known at this stage. A track-based system could be considered should the vehicle-mounted system prove to be ineffective. Even with a state of the art system, there is residual risk that squeal will occur some of the time.

In the event that noise levels exceed criteria with the above mitigation noise barriers may be used in some locations. The recommended extent of barriers is addressed in the 30% Design Noise Assessment Report. Individual house treatments may also be considered if barriers are determined to be impracticable.

It is recommended that detailed modelling of the rail/wheel interface is carried out at a later design stage to determine the expected contribution of rail noise to overall noise emissions, and therefore the potential benefit of rail dampers as a mitigation measure for curve squeal noise.

Both noise barriers and rail dampers are expected to reduce rolling noise in addition to curve squeal noise.

Other mitigation measures, such as rail head or gauge modification, and speed adjustments, are not recommended for curve squeal noise mitigation on Flinders Link.

5 References

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9

Flinders Link Detailed Design

Gateway South JV

Design Report - Elevated Walkway

FLD-RDP24-REP-9999-21-0001 | B

12 April 2018

Flinders Link Detailed Design

Project No: IW162000
Document Title: Elevated Walkway
Document No.: FLD-RDP24-REP-9999-21-0001
Revision: B
Date: 12 April 2018
Project Director Simon Kokar
Design Manager: Daniel Richter
Author: C. Zhao / S.Pointon
File Name: FLD-RDP24-REP-9999-21-0001

Document history and status

Revision	Date	Description	By	Review	Approved
A	15/12/2017	Issued for 30% Review	R Liu S Zevenbergen R Velisek	S Kerry	D Richter
B	12/04/2018	Issued for 70% Review	C. Zhao S Zevenbergen	S Kerry	D Richter

Contents

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs Group (Australia) Pty Ltd is to document the design in accordance with the scope of services set out in the contract between Jacobs Group (Australia) Pty Ltd and the joint venture of Fulton Hogan Construction Pty Ltd and Laing O'Rourke Australia Construction Pty Ltd trading as Gateway South ('the Client').

Jacobs derived the data in this report primarily from information provided by the Client, inspection of the Site by Jacobs, and with reference to relevant technical standards and guidelines available in the public domain. The passage of time, manifestation of latent conditions or impacts of future events may require further exploration at the site and subsequent data analysis, and re-evaluation of the findings, observations and conclusions expressed in this report.

In preparing this report, Jacobs has relied upon and presumed accurate certain information, (or absence thereof), relative to the Site provided by the Client and others identified herein. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information.

The findings, observations and conclusions expressed by Jacobs in this report are not, and should not be considered, an opinion concerning the technical standards. Further, such data, findings, observations and conclusions are based solely upon site conditions and information supplied by the Client in existence at the time of the investigation.

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1. Introduction

1.1 Project

The Flinders Link Project was announced by Federal and State Governments on 13 May 2016, with the two levels of government sharing equally the estimated $85.5m cost. The project comprises an extension of the Tonsley Rail Line to the Flinders Medical Centre, creating a new connection to the health precinct and Flinders University, with a terminus at Flinders Station.

The primary elements are:

- Rail viaduct providing a grade separated extension of the Tonsley line.
- Flinders terminus station.
- Integration with other transport modes:
  - An elevated walkway for pedestrians' access
  - bus connections on South Road.

1.2 Scope

This report addresses the 70% Design relating to the Structural, Civil and MEP Design for the Elevated Walkway and forms part of the Design Documentation for the package RDP24 – Elevated Walkway.

The drawings covered under this package are listed in Table 1-1.

Table 1-1: Package Drawings List

Drawing No.	Revision	Description
CS1-DRG-352231	B	TITLE AND INDEX
CS1-DRG-352232	B	NOTES AND LEGEND
CS1-DRG-352234	A	BAR SHAPE DIAGRAM DETAILS
CS1-DRG-352235	B	GENERAL ARRANGEMENT – SHEET 01
CS1-DRG-352236	A	GENERAL ARRANGEMENT – SHEET 02
CS1-DRG-352239	B	PILE DETAILS – SHEET 01
CS1-DRG-352240	B	PILE DETAILS – SHEET 02
CS1-DRG-352241	B	ABUTMENT A CONCRETE SHAPES - SHEET 01
CS1-DRG-352243	A	ABUTMENT A REINFORCEMENT DETAILS – SHEET 01
CS1-DRG-352244	A	ABUTMENT A REINFORCEMENT DETAILS – SHEET 02
CS1-DRG-352245	B	ABUTMENT B CONCRETE SHAPES - SHEET 01
CS1-DRG-352246	B	ABUTMENT B CONCRETE SHAPES - SHEET 02
CS1-DRG-352247	A	ABUTMENT B REINFORCEMENT DETAILS - SHEET 01
CS1-DRG-352249	B	ABUTMENT B REINFORCEMENT DETAILS – SHEET 03
CS1-DRG-352252	A	PIER 1 CONCRETE SHAPE
CS1-DRG-352253	B	PIER 1 PILECAP DETAILS
CS1-DRG-352254	A	PIER 1 HEADSTOCK SHAPES
CS1-DRG-352255	A	PIER 1 HEADSTOCK REINFORCEMENT DETAILS

Drawing No.	Revision	Description
CS1-DRG-352257	B	PIER 2 CONCRETE SHAPES AND STEEL FRAME
CS1-DRG-352258	A	PIER 2 PILECAP REINFORCEMENT DETAILS
CS1-DRG-352259	A	PIER 2 STEEL FRAME DETAILS
CS1-DRG-352261	B	BEARING SET-OUT AND DETAILS – SHEET 01
CS1-DRG-352262	A	BEARING SET-OUT AND DETAILS – SHEET 02
CS1-DRG-352269	B	MAIN SPANS STEEL FRAMING – SHEET 01
CS1-DRG-352270	B	MAIN SPANS STEEL FRAMING – SHEET 02
CS1-DRG-352271	B	MAIN SPANS STEEL FRAMING – SHEET 03
CS1-DRG-352272	B	MAIN SPANS STEEL FRAMING – SHEET 04
CS1-DRG-352273	A	MAIN SPANS STEEL FRAMING – SHEET 05
CS1-DRG-352274	A	MAIN SPANS STEEL FRAMING – SHEET 06
CS1-DRG-352275	A	MAIN SPANS STEEL FRAMING – SHEET 07
CS1-DRG-352276	A	MAIN SPANS STEEL FRAMING – SHEET 08
CS1-DRG-352290	A	DECK PANELS
CS1-DRG-352292	A	DECK SLAB
CS1-DRG-352294	A	DECK SLAB – REINFORCEMENT DETAIL – SHEET 01
CS1-DRG-352295	A	DECK SLAB – REINFORCEMENT DETAIL – SHEET 02
CS1-DRG-352310	B	ELECTRICAL SERVICES
CS1-DRG-352311	B	HYDRAULIC SERVICES
CS1-DRG-352312	A	SINGLE LINE DIAGRAM
CS1-DRG-352313	A	COMMUNICATIONS SCHEMATICS
CS1-DRG-352314	A	CCTV CAMERA COVERAGE
CS1-DRG-352315	A	ISOLUX COVERAGE
CS1-DRG-352318	A	DRAINAGE
CS1-DRG-352319	A	ACCESS ROAD CROSSING

2. Status

2.1 Hold Points

The Hold Points relevant to this package are summarised in Table 2-1

Table 2-1: Hold Points

Hold Point	CSTR Reference	Status
Selection of structure type & form	Part 35, Cl 2	Open
Bearing type submission	Part 35, Cl 3.2	Open
Bridge joint	Part 35, Cl 3.3	Open
Modifications to the existing roadways	Part D22 Cl 4	Open

2.2 Changes from previous revision

Table 2-2 summarises the major changes from the previous revision.

Table 2-2: Changes from notional 30% design to 70% design

Lot / Area	Description of Change	Benefit
Superstructure	The span of this elevated walkway has been reduced from 4 Nos to 3 Nos after omission of an intermediate pier between Abutment A and the Rest Point.	Optimisation of the structure
Substructure	The intermediate pier between Abutment A and the Rest Point has been omitted. Piers have been renamed. Abutment A has been revised to be an invert T shape instead of the L shape earlier used. The revision of Abutment A shape will make it more effective to resist the soil lateral pressure.	Optimisation of the structure
Foundation	The foundation supporting the intermediate pier between Abutment A and the Rest Point has been omitted. Piles at Abutment A have been revised from 6 Nos of Φ600 CFA to 4 Nos of Φ900 CFA.	Optimisation of the structure
Passenger Information Systems	The passenger information systems comprising a PID, VA and HIIL has been omitted from the scope of works	Simplification of the electrical isolation of the systems

3. Design Basis

The relevant design basis documents for this package are listed in Table 3-1.

Table 3-1: Design Basis Reports

Discipline	Document Number
Design Basis Report – Station Precinct	FLD-RDP01-REP-9999-32-0001

3.1 Site Assessment Report

For the site assessment report refer to FLD-RDP01-REP-9999-PMG-0001.

4. Compliance with CSTR

This design package complies with the requirements of CSTR with the exception of the noted departures. Table 4-1 shows the proposed departures for this package.

Table 4-1: CSTR Departures

Element	CSTR Reference	Departure	Acceptance
Bridge soffit	Part 35, Cl 3.4(a)	The minimum height to the underside of bridge soffit is less than 3.0m at abutment B. Clearance to underside is approximately 2.1m.	

A CSTR compliance register Requirements Analysis, Allocation and Traceability Matrix (RAATM) is attached in Appendix F.

4.1 Waivers

Table 4-2: Waivers

Element	CSTR Reference	Departure
CCTV Camera Mounting Height	Part D75 – Design – Station Security Systems, Cl 8.2.3 – Camera Mounting	The minimum height from floor level to the underside of the CCTV cameras is less than 3.0m. Fixed Dome CCTV Cameras have been used in lieu of PTZ to increase the lowest point on the CCTV camera, however 3.0m is not achievable due to constraints on the height of the bridge.
Luminaire Selection	Part D74 – Design – Electrical Infrastructure, Cl 6.2 – Light Levels, Table 6.3 (a) Type C	The present design proposes an alternative luminaire (details below). The purpose for proposing an alternative luminaire within the Elevated Walkway is to provide a solution with the luminaires recessed within the 'ceiling' (partly due to limited height clearances) which is expected to reduce the ability for vandalism whilst improving visual aesthetics. Selection : Xero Lighting - XTI, IP66, Vandal Resistant (IK10), Recessed Linear LED Luminaire Complete With DALI Control Gear - 1702mm x 80mm x 80mm.

4.2 Type Approval

Table 4-3: Type Approvals

Element	CSTR Reference	Status
Nil		

5. Safety Assurance Statement

Refer Safety Assurance Statement FLD-RDP01-REP-9999-PMG-0002

6. Technical

6.1 Structural

6.1.1 Substructure

The substructures comprise two piled reinforced concrete abutments at northern (Abutment A) and southern (Abutment B) ends and one piled reinforced concrete pier and another piled steel framed pier .

Abutment A is aligned with the retaining wall structures between the station and existing FMC Northern carpark with an overall wall height of approximate 4m. The abutment comprises an 800mm thick blade wall up to the underside of a 180mm thick and 5.0m long approach slab and a projected corbel which support the “floating” deck superstructure. This abutment wall and is supported on two rows of 2 no. 900mm diameter CFA piles 11m long. The two rows of piles will reduce lateral deflections to acceptable levels on the Abutment A wall due to earth pressures. Backfill to the abutment will be PM2/20QG. The retaining wall structure will be connected with the blade wall on both sides of Abutment A with hot dip galvanised dowel bars.

The back row of piles will not be subjected to a nett tension axial load for any of load combinations after adoption of the revised invert T shape abutment.

Abutment B comprises an 800mm thick blade wall up to the underside of the steel truss bearings which supports the deck superstructure. This abutment and is supported on 8 no. 600mm diameter CFA piles 9m long. The wall height from finished ground level to top of fender wall is approx. 2.5m. Backfill to the abutment will be PM2/20QG material.

The landing area integral with Abutment B comprises an L-shape retaining wall along the eastern elevation and a piled retaining system comprising 600mm diameter CFA piles 8m deep at 750 cts with 300mm thick wall on the western elevation. The area will be backfilled and a 150mm thick reinforced concrete slab on ground is be provided.

The blade wall at Abutment B transitions into a 250mm thick fender wall behind the end of the steel truss frame. There is a 5.8m long approach slab supported from the fender wall.

An assessment of the magnitude of the movement of the abutment blade walls due to lateral earth pressure will be completed at the next stage of design. The mechanical pot bearings will be provided at all abutments and piers to support the superstructures and accommodate the lateral movements due to thermal effects. Two transverse expansion joints will be provided at Pier 1 and Pier 2. The structure will be designed to ensure there is no uplift at the bearings.

Subsoil drainage will be provided behind the blade walls. Subsoil drain at Abutment A discharges to the adjacent stormwater open drain via weep holes provided in the retaining walls. Subsoil drain at Abutment B connects to an existing grated inlet pit in the services.

Pier 1 comprises a 1100 mm thick rectangular headstock panel supported on a 1200mm diameter column. Pile cap is a 3500mm x 3500mm x 1050mm deep supported on 4 no. 900 diameter piles 9.5m length.

Pier 2 comprises a steel frame supported on a 1300mm x 3670mm x 1050mm deep pile cap which in turn is supported on 2 no. 900mm diameter CFA piles at 7m length. The pier is designed to be pre-assembled, transported and installed at the final position.

Piers have been designed for a collision load of 300kN at 1.2m height.

The abutments and piers have been designed to resist lateral loading from earthquake and minimum lateral load provisions to AS 5100.2 - 2017 and AS 1170.4 - 2007. The elevated walkway structure has been classified as BEDC-3 in accordance with Section 15.4 of AS5100.2 and designed for an annual probability of exceedance of 1/1000 years. From AS1170.4 a Probability Factor (kp) of 1.3 was adopted.

Wind loading calculations have been undertaken and found to not be the critical lateral load design case.

6.1.2 Superstructures

The superstructures comprise three (3) spans steel framed trusses with constant width, and finished with reinforced concrete deck slab. The spans, from Abutment A, are 31.715m, 34.484m and 18.013m long and truss depth of 2.86m and width of 3.63m between centrelines, refer Figure 6.1and Figure 2. Typical section of the structure is shown in Figure 6.3.

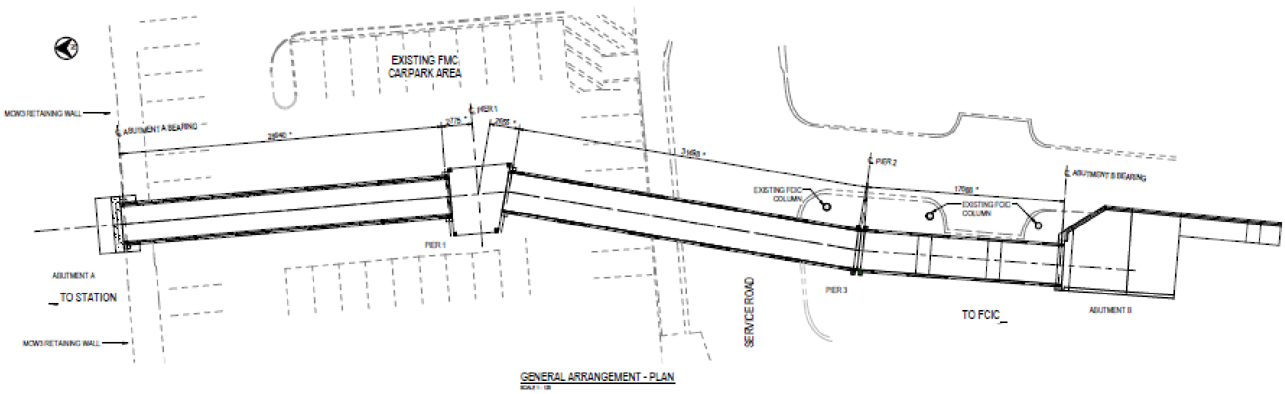

Figure 6.1 : Elevated Walkway Arrangement – Plan

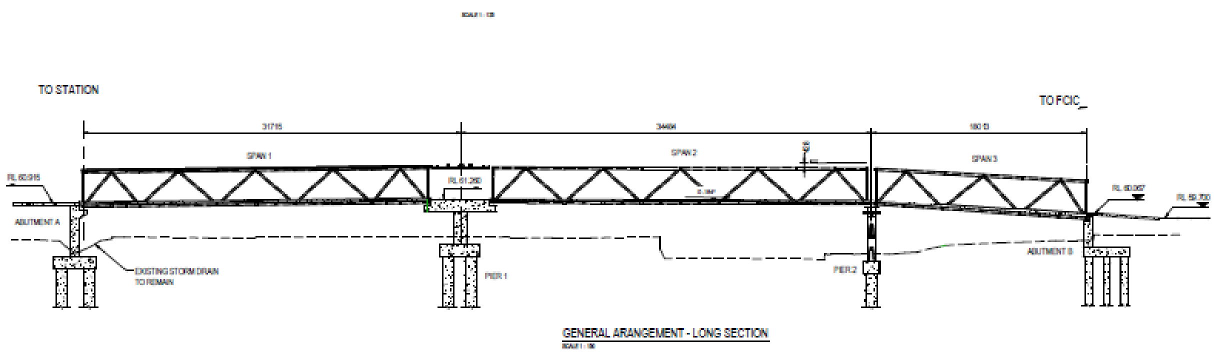

Figure 6.2 : Elevated Walkway Arrangement – Elevation

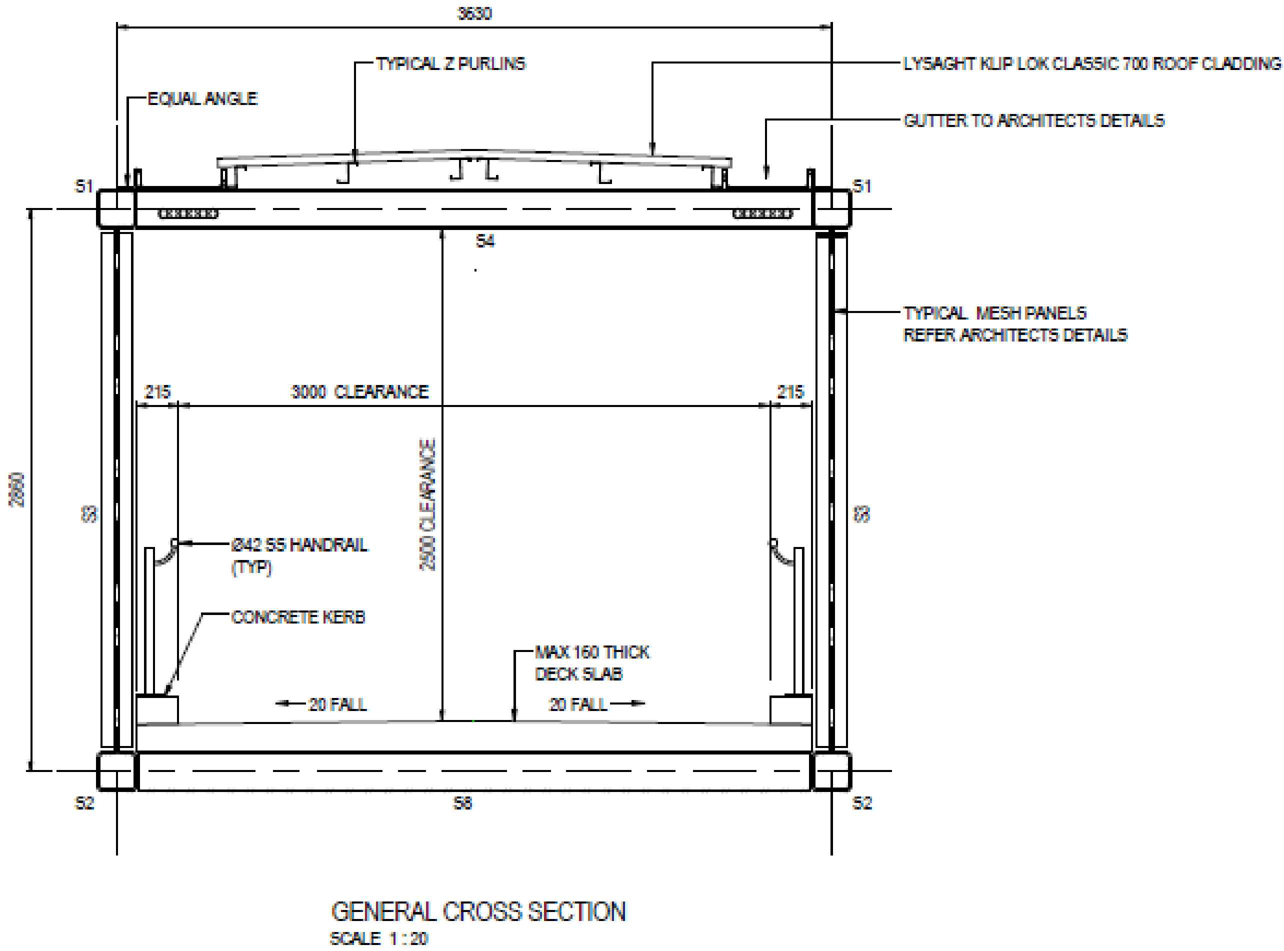

Figure 6.3 : Typical Elevated Walkway Section

The proposed elevated walkway alignment is over the existing FMC Northern carpark, over the Northern service road and under the existing FCIC building and ties into the existing building landing. It maintains the following clearance to existing facilities:

- Northern carpark is height restricted to 2.1m. Minimum vertical clearance to the underside of the elevated walkway is 2.8 including over the carpark aisle. Minimum vertical clearance to the underside of Pier 1 is in the order of 2.0m. A cladding system and landscaping is being considered to discourage access beneath the pier.
- Vertical clearance of 4600 mm above existing northern service road
- Vertical clearance of 160 mm to soffit of FCIC building from elevated walkway ridge.

Each bridge span is designed to be pre-assembled with typical welded connection, being transported and installed at final position. Further description of construction sequencing for the superstructure is provided in Section 7.5 of this report.

The superstructures are supported on piers and abutments via mechanical pot bearings. The arrangement of bearings is summarised in Table 6.1.

Table 6.1 : Bearing types and locations

Description	Bearing Type
Abutment A	1 x fixed bearing (fixed in both transverse and longitudinal directions). 1 x guided bearing (fixed in longitudinal direction).
Pier 1	1 x free floating bearing 1 x guided bearing (fixed in transverse direction) 1 x guided bearing (fixed in longitudinal direction) 1 x fixed bearing (fixed in both transverse and longitudinal directions).
Pier 2	2 × free float bearing. 2 x guided bearing (fixed in transverse direction).
Abutment B	1 x fixed bearing (fixed in both transverse and longitudinal directions). 1 x guided bearing (fixed in longitudinal direction).

2 Nos of expansion joints are to be provided at Pier 1 and Pier 2 to release the thermal effects on the bridge substructure.

Allowance for jacking points at the piers and abutments for bearing replacement has been made below the transverse beam S8. Locations will be documented in the next stage of design. It is expected that access to the bearings for maintenance and replacement will be via an elevated work platform.

A positive lateral restraint system between the superstructure and the substructure will be provided at piers and abutments to resist a minimum 200 kN or 5% of the superstructure dead load for the elevated walkway as per AS 5100.2 - 2017 Clause 10.

6.1.3 Safety Screen

A risk assessment was conducted on the 30 October 2017 to assess the extent of safety screens for the Flinders Elevated walkway, refer to TAN011. The risk ranking score was 22.8, below the recommended score of 30 at which safety screens are recommended to be provided, notwithstanding this though, the following recommendation has been adopted in the design:

- Safety screens will be provided for the entire length of the bridge and will be designed as pedestrian barriers as per AS 5100.1 and AS 5100.2.

6.1.4 Method of analysis

The analysis of the bridge was carried out through an equivalent three-dimensional computer model created using a proprietary software SpaceGass. The model has included both superstructure and substructure components to fully understand the local and global behavioural responses of the integral bridge. Both ultimate and serviceability analysis have been included.

The bridge has been designed as a pedestrian walkway structure with the following:

- Permanent action of structural steel elements generated by SpaceGass with additional 10% allowance for connection.
- Permanent action of 190mm thick reinforced concrete deck with density of 26 kN/m3.
- Permanent action of 0.50 kPa for roof structures.
- Permanent action of 0.50 kPa for cladding
- Permanent action of 0.25 kPa for services being supported at roof.
- Permanent action of 0.25 kPa for services being supported at deck slab.

- Permanent action of 1.0 kN/m for pedestrian steel hand rails including a 100mm high concrete kerb.
- Imposed live load of 5.0 kPa at deck in accordance with AS 5100.2 - 2017.
- Imposed live load of 0.25 kPa for allowance of maintenance at roof.

6.2 Geotechnical Design – Summary of Subsurface Conditions

6.2.1 Regional Geology

Reference was made to the Department of Mines and Energy (1983) Geological Survey of South Australia – Noarlunga Map Sheet (1:50,000) and the 1:50,000 scale Soil Association Map of the Adelaide Region.

Based on those published maps, the site is expected to be underlain by a poorly developed soil profile comprising slope wash (colluvial) materials or skeletal soils. The surficial soils are shown to be underlain by weathered bedrock (Tapley Hill Formation). Lower down the slope clays bellowing to the Pooraka and Hindmarsh formations are present, but are covered with several metres of backfill used to construct the Flinders University Playing Fields.

6.2.2 Available Geotechnical Data

A site specific geotechnical investigation has been completed for the bridge piers by Golder Associates:

- Golder Associates (Darlington Upgrade Project: Flinders Link Supplementary Geotechnical Investigation, Report 1790212-001-R-RevA 22 March 2018).

The site investigation included a total of one CPT (CPT509) and four boreholes (BH518 to BH521) along the bridge alignment. The boreholes were positioned as close as possible to bridge pier and abutments locations; however, it is noted that two piers originally proposed within the carpark have now been combined into a single pier. The target depth of the boreholes and CPT was 14 m, however all encountered refusal prior to the target depth.

In addition to the site investigation, a desktop study of other available geotechnical information was completed. Reference was made to the following documents, which provided a further understanding of the likely subsurface conditions:

- Golder Associates. August 2015. Darlington Upgrade Project: Adelaide, South Australia. Stage 5 Geotechnical Investigation – Flinders Link, specifically BH404 and BH403 located approx. 30 m north of Abutment A.
- Department of Mines Report DM72/27 'Flinders Medical Centre - Bedford Park Geological Investigations Report No. 2 Design Stage' dated February 1972. Topographic survey, geophysical and boreholes investigation
- Jim Wilson Consulting Engineers, 10 September 2015, 'FMC Car Park Subsidence' Job No. 3934.
- Coffey Geotechnics,14 January 2009, 'Flinders Medical Centre – New Cancer Unit Bedford Park Geotechnical Investigation' report 05776/AA-AB

6.2.3 Geotechnical Model

Based on the available geotechnical information, the subsurface profile along the bridge alignment was divided into four geotechnical units. The units are described on Table 6-2 and the inferred depth of the units at each borehole are summarised on Table 6-3.

BH520 and BH521 both report the presence of 'bedding planes' prior to borehole refusal and 'inferred residual soil to extremely weathered rock' at 6.5 m to 8.0 m depth. This observation is a possible indication of a transition to the Tapley Hill Formation.

SPT testing was completed as part of the geotechnical investigation. A plot of the SPT 'N' values against depth is provided as Figure 4.

Table 6-2: List of inferred geological units

Unit	Description
Fill	Includes backfill placed behind the carpark retaining wall and backfill used to construct the Flinders University Playing Field (several metres thickness). Comprises varying proportions of medium plasticity sandy clay, gravel and sand (probably colluvium material sourced from higher up the hill). Variable strength, subsidence has been observed in the carpark suggested some areas of poor compaction. During construction of the carpark boulders were encountered in the fill, which may pose problems for pile construction.
Calcareous Soils	Clay with white calcareous (calcium carbonate) mottle and some sand and gravel. Generally dry and stiff to hard consistency
Slope Wash / Colluvium	Interbedded layers of: Clay: medium to high plasticity, grey and red brown, generally very stiff to hard consistency; Gravel: poorly graded excess clayey and silty fines, mainly shale, slates and fine to medium grained sandstone, slightly to highly weathered, sub rounded; and Sand: excess clayey fines, grey and brown
Tapley Hill Formation	Local bedrock, a laminated dark blue/grey, slightly calcareous, often pyritic siltstone.

Table 6-3: Inferred Stratigraphy (in m below top of borehole)

Description	BH404	CPT509	BH518	BH519	BH520	BH521
Nearest Structure	18 m North-East of Abutment A	Abutment A	Pier 1	Pier 1	Pier 2	Abutment B
Fill	0.0 m - 6.4 m	0.0 m - >4.82 m (refusal)	0.0 m – 6.0 m	0.0 m to >2.1 m (refusal)	0.0 m - 1.2 m	0.0 m - 1.2 m
Calcareous Soils	6.4 m – 10.0 m (limit of investigation)		6.0 m – 7.75 m		1.2 m - 3.0 m	1.2 m - 3.2 m
Slope Wash / Colluvium			7.75 m – >12.45 m (refusal)		3.0 m – > 7.95 m (refusal)	3.2 m – > 9.8 m (refusal)

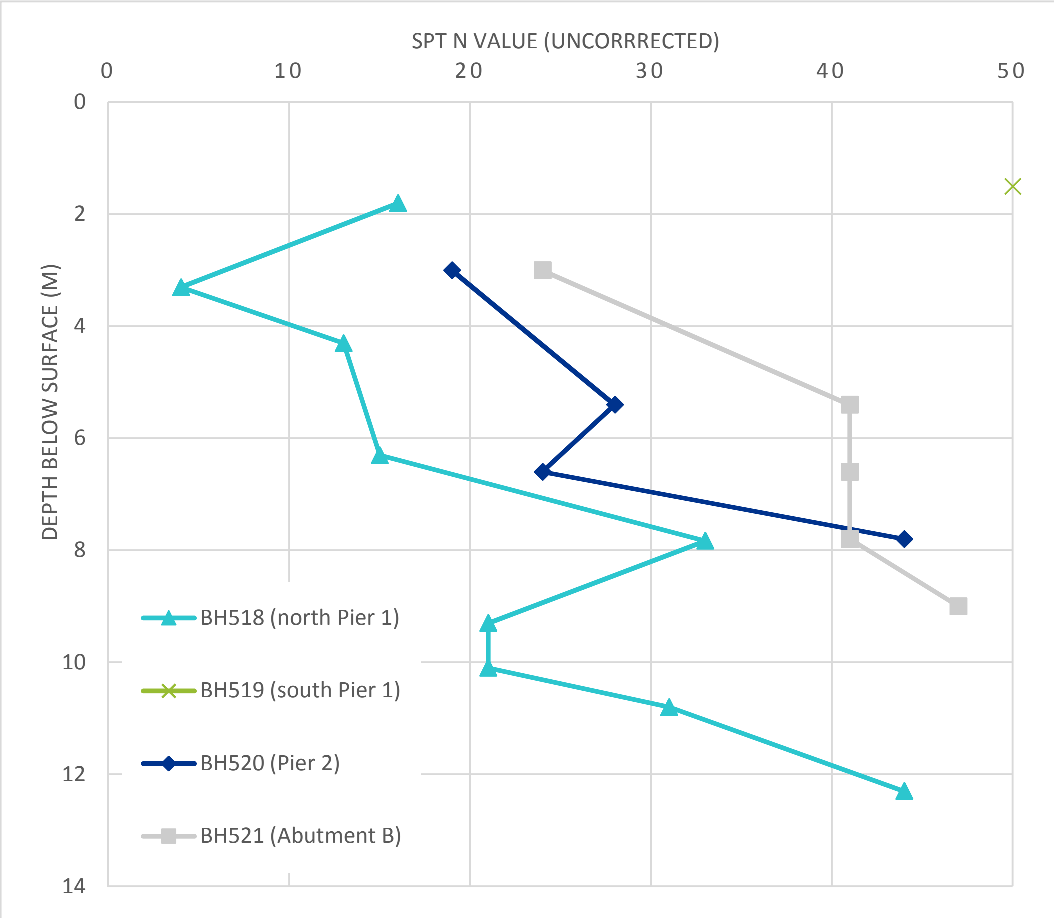

Figure 6.4 : Plot of standard penetration test 'N' Value against depth

6.3 Geotechnical Design – Foundation Design

6.3.1 Foundation Design Considerations

Piles are proposed to support the bridge foundations due to geometric constraints imposed by existing spread footings at pier 2 and the presence of existing fill at Abutment A and Pier 1.

Bored or continuous flight auger piles are proposed; as driven piles are considered unsuitable due to the likelihood that noise/vibration during pile driving could adversely impact on the operation of the adjacent hospital.

A challenge at this site is the potential for boulders to be present within the fill. SMEC have been advised that during construction of the Flinders Medical Centre Carpark in 2005 (AES500) the contractor recovered boulders up to 1 m^3 size while excavating for the lowest of the carparks. Use of specialist pilling equipment may be required to clear obstructions if any boulders are still in place.

6.3.2 Geotechnical Design Parameters

Geotechnical parameters were assigned for each geological unit based on the in-situ test data (SPT, pocket penetrometer) and the borehole log descriptions. The parameters nominated are listed in Table 6-4.

The engineered fill is specified as a granular PM2/20 quarry product (DPTI Standard Part R15 Attachment A) to be placed behind the bridge abutments and adjacent retaining walls.

Table 6-4: Geotechnical Parameters adopted for design

Unit	SPT N Value	Bulk Unit Weight (kN/m3)	c_u (kPa)	c' (kPa)	Φ' (°)	fs (kPa)	fb (kPa)	Ev.u (MPa)	v'
Engineered Fill (PM2/20)	-	20	-	0	38	NA	NA	40	0.25
Existing Fill	4 to Refusal	16	-	0	30	25	NA	20	0.25
Calcareous Soils	15 to 33	20	100	5	30	50	900	30	0.25
Slope Wash / Colluvium	21 to Refusal	20	200	10	30	80	1800	60	0.25

Notes

- c_u = undrained shear strength of cohesive materials;
- c' / Φ' = long term (drained) cohesion and friction angle;
- f_s = pile shaft adhesion
- f_b = pile base capacity, taken as Nc * cu, with Nc = 9.
- E_u = undrained Young's modulus
- v' = Drained Poisson's ratio based on typical values for the materials.

6.3.3 Groundwater

The regional groundwater table was not intercepted by any of the boreholes drilled along the bridge in the station precinct. Given the elevated position of the site, the regional groundwater table is expected to be located well below the pile tip.

6.3.4 Geotechnical Reduction Factor

In accordance with AS2159-2009 "Piling – design and installation." a geotechnical strength reduction factor, (ϕg), must be applied to the ultimate geotechnical parameters. For this design package, a ϕ_g value of 0.67 was nominated for the bridge piles in accordance with AS2159 to reflect uncertainties and variability in the subsurface profile and the proposed testing regime.

6.3.5 Pile Design Summary

The geotechnical capacity of the piles (in compression) have been calculated in accordance with AS2159 and the parameters on Table 6-4. The pile design is summarised in Table 6-5.

The anticipated ground conditions at the base of Pier 2 and Abutment B piles is a hard-gravelly clay / weathered rock.

The anticipated ground conditions at the base of Abutment A and Pier 1 piles are very stiff to hard clays. The piles have been proportioned to extend at least 2.5 m into the natural soils underlying the fill (fill 6 m to 6.5 m thickness)

Negative skin friction due to further subsidence of the fill was considered. The modelling found that further ongoing consolidation of the fill is likely to relatively small and is not expected to be critical to the pile serviceability or structural design

Table 6-5: Summary of pile design

Location	Pile Cut-off Level	Design Pile Diameter	Minimum Pile Embedment	Factored Pile Capacity kN (Φg x Rug)
Abutment A	TBC	900 mm	9.0 m	1450 KN
Pier 1	TBC	900 mm	9.5 m	1600 KN
Pier 2	TBC	900 mm	7.0 m	1900 KN
Abutment B	TBC	600 mm	9.0 m	1250 KN
Retaining wall at Abutment B	TBC	600 mm	8.0 m	N/A

6.3.6 Pile monitoring and testing

The installation, monitoring and testing of piles shall comply with DPTI Specification Part S16 – Cast in Place Concrete Piles (or DPTI Specification Part S17 – Continuous Flight Auger Piles if applicable).

A minimum of one dynamic pile compression test shall be completed at each pier and abutment pile group.

Integrity testing must be completed on each pile in accordance with the DPTI specification and the integrity test methods specified in AS 2159.

6.3.7 Parameters for structural modelling of piles

Based on the anticipated ground conditions the modulus of subgrade reaction values for use in structural modelling of piles up to 900 mm dimeter are suggested in Table 6-6. Due to uncertainty regarding the modulus values It is recommended that sensitivity analysis be performed using 50 % and 200 % of the quoted values to check if unforeseen effects are produced.

Table 6-6: Subgrade Reaction Modulus Values for Piles

Unit Name	Vertical Constants		Lateral Constants
	pile shaft k_s (kPa/mm)	pile base k_b (kPa/mm)	k_h (kPa/mm)
Fill	10	-	7
Calcareous Soils	16	37	11
Slope Wash / Colluvium	32	74	22

6.3.8 Abutment B Retaining Wall

An existing post and panel retaining wall (approx. 2m high) supports an excavation for a tank (refer Figure 5). The new bridge abutment will have a surface level approximately 1.5 m higher than the current level. To facilitate the new surface, a higher retaining wall is required to be installed between the water tank and Abutment B. It is proposed to build the wall behind the existing retaining wall, making that structure redundant. The new retaining wall will retain approximately 3.5 m to 4 m of soil.

Figure 6.5 : Existing Retaining wall:

The retaining wall is to be supported a row of 600 mm diameter piles. Analysis of the wall was completed using the software package WALLAP. The WALLAP model configuration was as follows:

- Soil parameters in accordance with Table 5-4.
- 5 kPa surcharge behind the retaining wall
- wall drained / no hydrostatic pressure (NYLEX drainage blanket to be installed behind upper part of the wall)
- Seismic load case with 0.1g quasi-static horizontal force

The analysis found the following:

- Top of wall deflection: : < 15 mm
- Max. Bending Moment in Pile (ULS Seismic case) : 144 kNm/m

It is noted that the CSTR does not specify any limits for deflection for retaining walls. Movement of the existing H-Beam concrete sleeper wall is to be monitored during construction of the piles and if necessary temporary buttressing / propping installed.

6.4 Drainage

The deck surface will have a cross-fall from centre towards both sides. A kerb is provided on each side to prevent stormwater or waste water from cleaning machines discharging over the edge.

The elevated walkway roof will adopt a typical gutter to downpipe drainage system. The roof will have a cross-fall from centre towards roof gutters which will run both sides of the roof. The gutters will tie-into proposed down pipes which will be located at both ends of the elevated structure at Abutments A and B. Downpipes at abutment A will discharge into the open drain, while downpipes at abutment B will discharge into an existing grated inlet pit adjacent the service road. No downpipes are proposed at any of the piers.

6.5 Services

6.5.1 Cabling Reticulation

Electrical and Communications cabling for the Flinders Elevated Walkway is supplied via a network of pits, conduits and local distribution boards. These reticulate from street level at the eastern abutment and the station equipment room through the plaza ultimately to the walkway.

A non-isolated, low voltage electrical and copper communications service is to reticulate from a Main switchboard and local Telstra pit located at the street level of the eastern abutment. Submains and copper communications cabling 'lead in' are to reticulate in segregated electrical and communications conduits up the terrain. Alongside this route of cabling will also be an isolated electrical supply to service the station Equipment Room. A non isolated supply is required due to the plaza and elevated walkway areas being located outside of the Common Bonded Earth Network (CBEN) The non isolated electrical supply, is to reticulate through conduits and pits to a local distribution board, located at the southern perimeter of the plaza area. This distribution board is responsible for providing electrical supply to plaza and elevated walkway lighting and power circuits. The distribution board will also contain DALI lighting control gear for the luminaires located on the elevated walkway.

Cabling within the Flinders Elevated Walkway is reticulated via 150mm (W) cable trays (2off total). Due to physical space restrictions within the cavity above the ceiling, the proposed cable trays are mounted 'upside down' to allow cabling to be reticulated from below and fixed to the tray with cable ties. Formed penetrations in accordance with regular structural requirements are to be provided within structural elements to allow cabling to pass through.

6.5.2 CCTV Cameras

The Flinders Elevated Walkway has been provided with 6off surface mounted 'fixed' CCTV cameras (Indigo Vision Vandal Resistant 'Mini Dome' series in accordance with DPTI approved equipment). CCTV cameras are located to provide total overall coverage of the Flinders Elevated Walkway. CCTV cameras will be connected back to the station Common Equipment Room (CER) via a Field LAN Switch (FLS) located within the station precinct.

The FLS is to be located at the rest area of the walkway. A 12 core optic fibre connection is to reticulate from the station equipment room to a switch within the FLS. Utilising a fibre optic cable from the Equipment Room will provide the appropriate isolation for the area outside of the CBEN area. From this switch within the FLS category 6 copper cabling is to reticulate to each of the CCTV cameras. A UPS is to be accommodated within the FLS and powered via a local electrical circuit from the plaza distribution board. The UPS will provide backup power to the switch and CCTV systems along the elevated walkway.

6.5.3 General power

An electrical submain connection is to provide a non isolated electrical supply from the Main Switchboard located at the street level of the eastern abutment. As described in section 6.5.1 Cabling Arrangement electrical submains cabling is to reticulate up the bank within a segregated conduit and pits to the plaza distribution board. The plaza distribution board will provide electrical and DALI lighting sub circuits to the plaza and elevated walkway supplies. Cabling along the elevated walkway is to reticulate via an overhead 150mm wide cable tray.

3off 15A single phase General Purpose Outlets (GPO's) are to be provided to the Flinders Elevated Walkway. Socket outlets are to be recessed at 2000mm Above Finished Floor Level (AFFL) within structural columns and provided with a lockable cover in accordance with DPTI standards.

6.5.4 Lighting systems

A Digital Addressable Lighting Interface (DALI) lighting control system is to be installed within the plaza distribution board located on the southern side of the plaza area. The lighting system will incorporate DPTI standard DALI hardware to provide automation and control from the central control room location. All lighting throughout the Flinders Elevated Walkway is proposed to be high efficiency LED type with 4000K lamp colour temperature and with vandal proof accessories. Lighting is to be fixed to the Flinders Elevated Walkway ceiling structural member to reduce potential for vandalism and tampering of luminaires. Emergency luminaires will be of the same luminaire type, however, will consist of an external emergency backup pack located external to the luminaire, concealed above the ceiling. This is expected to assist with battery replacement in the future if required.

Table 6-7 provides a summary of the simulated resultant illuminance level throughout the Flinders Elevated Walkway. The luminaires are positioned in such a way to meet DPTI standards for 'covered areas'. Lighting has been designed in accordance with the Disability Standards for Accessible Public Transport 2002 Part 20:Lighting which stipulates a level of 150 lux on the horizontal.

Table 6-7: Simulated illuminance level throughout Flinders Elevated Walkway

Calculation Summary							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
Elevated Walkway_Floor	Illuminance	Lux	158.48	228.2	46.8	3.39	4.88
Elevated Walkway_Workplane	Illuminance	Lux	157.57	213.3	89.4	1.76	2.39
Horizontal	Illuminance	Lux	158.54	213.3	89.4	1.77	2.39

6.5.5 Hydraulics services

A 25mm potable cold water supply shall extend from the station platform to the new Flinders Elevated Walkway. The pipework shall be suspended and fixed to the structure utilising non corrosive brackets and fixings. Three off taps shall be provided along the Walkway located at equal intervals and installed within a purpose built non-corrosive valve box complete with non-slip lid. Valve box shall vertically mounted flush with the finished walkway internal surface and located on the side of the walkway as to not to impede any access requirements. A type M padlock shall be fitted the valve box lid. The valve box shall be provided with weep hole to permit condensation and excess water to drain from the box.

6.6 Durability

6.6.1 Concrete Elements Exposure Classifications

6.6.1.1 Atmospherically Exposed

Two deterioration mechanisms are relevant for above ground reinforced concrete elements:

- Chloride-induced corrosion (from deposition and ingress of air-borne chlorides);
- Carbonation-induced corrosion.

The basic exposure classifications for reinforced concrete elements stipulated by AS 5100.5 are:

- B1 - where a structure is located between 1km and 50km of the coastline;
- B2 - where a structure is located within 1km of the coastline.

As the project is more than 1 km from the coastline, a B1 exposure classification is considered adequate for above ground reinforced concrete elements.

6.6.1.2 Buried Soil and Groundwater Exposure

Based on soil test results, the soils across the site are alkaline (pH>5.5) with low sulphate (<1000ppm) and low chloride content (<2000ppm), refer Geotechnical Interpretive Report FLD-RDP03-REP-9999-04-0001. The soils can therefore be classified as "non aggressive" for concrete in accordance with AS5100.5. A B1 exposure classification has been adopted for buried concrete elements.

6.6.2 Steelwork

Atmospheric corrosion of metallic elements is generally due to several important factors which affect the corrosion rate of metals. These include time of wetness (which is the period of time during which a metallic surface is covered by a film of water rendering atmospheric corrosion possible) and pollutants such as airborne salt (which is a major stimulant of atmospheric corrosion in coastal regions of Australia).

The elevated walkway structure will be exposed to the prevailing atmospheric conditions. These are summarised below:

- Flinders Link project is located some km 4.8km off the coastline
- Annual rainfall is approximately 620mm
- Annual mean maximum and minimum temperatures are 20.9 degrees Celsius and 12 degrees Celsius respectively.

In order to classify a particular exposure environment, it is necessary to compare the geographical location and exposure conditions at the site with the corrosivity descriptions given AS 2312.1 and AS4312. Table 6-8 summarises the descriptions in AS 2312.1 and AS4312 of the atmospheric corrosivity classifications for the station assets and sub-assets and provides corrosion rates for the metals likely to be used in their construction.

Table 6-8: Summary of corrosivity classifications and corrosions rates

Corrosivity Category (AS/NZS 2312.1 and AS 4312)	Typical Environment	Corrosivity	Corrosion Rate (source: ISO: AS2312)		Practical Environment
			Carbon Steel (µm/yr)	Zinc (µm/yr)	
C3: Medium	Coastal/Industrial Areas with low salinity. Generally 50 m from the shore to 3-6km inland	Medium	25-50	0.7-2.1	Mild marine or mild industrial. For a less sheltered bay or gulf, such as near Adelaide, this category extends from 100 m from the shoreline to about 3-6 km inland

A C3: Medium corrosivity classification has been determined for the internal and atmospherically exposed metallic assets and sub-assets associated with the Flinders Station

6.6.3 Protective coating systems

Selection of the protective coating system has been based on Table 6-9 of AS 2312.The life expectancy of painted items is dependent on the environment and coating thickness and is summarised in the following table for a C3 environment.

Table 6-9: Life expectancy of protective coating systems for Category C3

System Designation	Nominal Coating Thickness (micorns)	Durability – Years to first maintenance (Atmospheric Corrosivity Category C3 Medium)
PSL 2	325	25+

The PSL 2 coating systems consists of:

- Zinc rich primer with nominal DFT of 75µm
- HB epoxy with nominal DFT of 175µm

- Organic polysiloxane top coat with nominal DFT of 75μm

Friction grip bolted connections within the steel bridge components, tested in accordance with AS 5100 Appendix J, will be coated with 75 micron (DFT) zinc rich epoxy coating.

6.7 FMC Northern Access Road Crossing

A wombat crossing at the Northern Entrance Access road where the ramp from the elevated walkway FMC plaza meets the existing footpath is proposed. The wombat crossing width shall extend to include the existing stair from the adjacent veranda. The crossing shall be installed in accordance with DPTI Manual of Legal Responsibilities and Technical Requirements for Traffic Control Devices Part 2 – Code of Technical Requirements. The crossing is consistent with over similar pedestrian crossings in the Flinders Medical Centre precinct.

6.8 Issues to be resolved in the next phase.

- Modification of the fire sprinkler system to the FCIC building over the elevated walkway
- Possible provision of fence/screen at abutment B where vertical clearance is limited to 2.1m
- Integration of the water points within the structure

7. Design Integration

7.1 Digital

Throughout the design development process the design team has utilised a BIM workflow to integrate the 3D design modelling across each of the design disciplines. A project Digital Engineering Execution plan has been developed and is being used through the detailed design phase (FLD-RDP01-STD-9999-ENG-0002) to detail the processes to incrementally develop a fully integrated 3D model. This model is updated weekly, used for our weekly coordination meetings and issued as a federated Navisworks model for all parties to undertaken an ongoing review.

7.2 Environmental

7.2.1 Environmentally Sensitive Areas

As per the CSTR (D20, Section 6) the "design of the Works and Temporary Works must minimise the impact on any environmentally sensitive areas" and environmentally sensitive areas (ESAs) should be clearly shown on design drawings and translated onto Site Environmental Plans / Environmental Control Plans. Within the footprint of Flinders Station the Elevated Walkway background data suggests that ESAs include minimal vegetation and low risk heritage features.

Background data suggests that ESAs for the Flinders Link Project include amenity vegetation, and low risk Heritage areas (e.g. areas that have been previously disturbed) and low risk heritage sites (e.g. a modern sculpture near the FMC carpark where the pedestrian bridge will be built). Ecological and Heritage Gaps Analysis TANS (050 and 048, respectively) highlight areas of the Flinders Link Project area that are outside the wider Darlington Project area.

The design process will minimise impacts to native flora, significant trees, Aboriginal Heritage and non-Aboriginal Heritage sites. Spatial data of Environmentally Sensitive Areas will be incorporated into drawings, where required and will be covered in package RDP25-Environmental. Detailed vegetation removal information is documented on vegetation removal drawings in package PDP25 70% design.

Flora and Fauna

Vegetation surveys have been undertaken as part of the Darlington Project (EBS 2014, 2016). A gaps analysis indicated minor areas of the Flinders Link project area that were not included in the surveys and are summarised in TAN (050). A survey of the areas not done previously will be undertaken, if required. Minimal amenity vegetation is present within the footprint, there are several regulated trees that will be removed or pruned closer to Tonsley Station. Vegetation removal will be documented in a separate Design Package – RDP25 (Vegetation Removal Drawings) at 70% design.

Heritage

Several non-Aboriginal Heritage items also occur within the vicinity of the project area (e.g. Fairford House, Coach House, Pumping Shed and Ford). The Heritage TAN (048) outlines the low risk for the project in terms on non-Aboriginal Heritage. Vibration impacts are also discussed in TAN 048 and are considered to be negligible, based on vibration studies for Darlington. TAN 048 also summarises Aboriginal Heritage for the Flinders Link project, following review of EBS 2017. The majority of the Flinders Link footprint is considered to be low-moderate risk and there are two small high risk areas (based on location and lack of previous disturbance).

Heritage risks will be managed during construction in accordance with recommendations in EBS Heritage 2017. Recommendations for high risk areas (as per TAN 048) include:

- Excavation monitoring in undisturbed soils until heavy compact clay / and / or rock (where archaeology will not be present) – though noted that the existing Gateway South JV procedure on the Darlington Upgrade

Project includes exemptions which may extend to Flinders Link. These include no monitoring during piling / auguring, and no monitoring where disturbance is less than 200 mm BGL.

- Continue to implement the existing Gateway South JV site discovery / recovery procedure. Noting that DPTI guidelines for Aboriginal Objects, Sites and Remains: Discovery Guideline, DPTI 2013, (FLINKP1-DPTI-REP-0000-TEN0011) are also available. This guideline provides decision tools for areas within and outside section 23 authorization areas, communication protocols etc.

Recommendations for low – moderate risk areas include:

- Continue Cultural awareness training during induction as per existing Gateway South JV procedure
- Continue to implement the site discovery / recovery procedure as per Gateway South JV existing documentation.

In addition, EBS Heritage (2017) identifies a modern sculpture that is present within the footprint of the elevated walkway that will be impacted. This sculpture is not protected under heritage legislation. It was created by Aboriginal artist Karl Telfer and cultural geographer Gavine Malone on commission from the Flinders Foundation.

Contamination

A contamination TAN is being prepared (TAN 049) summarising the understanding of soil and groundwater contamination in the area of the proposed Flinders Link project based on a desktop review of documentation provided and publically available information sources.

Water Quality

As described in Section 6.4 stormwater runoff is proposed to either drain directly to the existing drainage system as per current arrangements (ballasted track) or drain into the a new bioretention basin for treatment and detention (viaduct). Runoff from the basin is then discharged to Sturt Road drainage system and ultimately to Sturt River.

As required by the CSTR (Part D20, Section 8.2) a Water Quality Risk Assessment (WQRA) will be complete in accordance with DPTI's Protecting Waterways Manual at the next stage of design to inform design optimisation and options assessment.

The provision of the WQRA documentation with the final design shall constitute a HOLD POINT.

Noise and Vibration

A preliminary noise modelling was undertaken. Noise walls are to be installed only if the post construction noise levels exceeds the criteria.

A Sustainability Management Plan (SMP) has been prepared as part of the project. Outcomes of the Ecological Sustainable Development (ESD) acquittal were provided as part of RFI 040. DEWNR's Climate Change Unit approved the SMP and notes the inclusion of commitments on Ecologically Sustainable Development Strategies. It is also noted that during the detailed design phase a CEMP will be developed which will be used to minimise impacts to the environment.

The design incorporates the following initiatives:

- Pre-fabricated steel structures which improves efficiency in the construction process and reduces construction activity on site (reduces community disruption, noise, water and energy use on site)
- Continuous flight auger piles are proposed to minimise noise/vibration impacts on the operation of the adjacent hospital.
- The drainage design ties-in to the existing carpark drainage system which minimises the need for additional infrastructure.

- High efficiency LED lighting with vandal proof accessories to minimise energy use and replace/maintenance requirements.

The SMP was prepared by DPTI for the Public Works Committee submission, which identifies identified a range of sustainability benefits of the Flinders Link project and additional opportunities to enhance sustainability.

A Sustainability in Design Workshop was held on 30th November 2017 as per the CSTR (part D20, Section 5). Discussion at the workshop highlighted the importance of addressing connectivity with existing and future greenways and walking/cycling routes, integration with existing and planned future land use to enable sustainable development and opportunities to reduce material use and minimise waste. Drainage design for this package aligns with these principles in terms of not altering major flow paths, discharging into existing drainage system, minimising the need for additional infrastructure. The outcomes of the workshop including initiatives and actions were documented in a report and have been provided to DPTI. Further discussions with DPTI / GWS are required regarding initiatives and further actions to that will inform future stages of the design..

7.3 Interdisciplinary Review

Prior to issue this package has undergone an interdisciplinary review. The evidence of this review is provided in Interdisciplinary Review Appendix B.

7.4 Safety in Design

Safety in Design is integral to all stages of design development and has been considered throughout this package. A number formal safety assessment workshops have been conducted, including:

- 30% Design HAZOP and Safety in design Workshop on the 21st November 2017
- Safety Impact Assessment Workshop on the 16 February 2018
- 70% Design HAZOP and Safety in Design workshop on the 9 March 2018

The Safety in Design register is contained within the project Safety in Design Report (17510-REP-001). A summary of the items identified that related to this design package is provided in Table 7-1.

Table 7-1: Safety in Design Items Relating to the Elevated Walkway

ID	Issue / Description	Safety Related Requirements / Application Conditions	Status
3.5	The proposed precinct design includes a pedestrian walkway that allows people to move between the new station, access to lifts to the lowered roadway for access to bus stops etc. and traverse of the Flinders staff carpark to access university and hospital buildings. The pedestrian walkway crossing of the University Hall Access Road will introduce height restrictions for vehicles accessing the area. Lifting the trusses for span 3 & span 4 under the existing building Installing CFA Piles for pier 3 under the FCIC Piling vibration impact Piling adjacent to the existing retaining wall	SRR/SRAC: 3.5.1 - The project shall ensure that emergency services and maintenance/delivery vehicle access is not compromised by the proposed pedestrian walkway. This shall include a consideration of height clearance requirements of crossing to allow vehicle access. 3.5.2 - Provision of a definite entrance to the station from eastern side shall be considered to avoid diverting all traffic to the western walkway.	Clearance heights have been confirmed and negotiation of access from shared areas in the vicinity of the Flinders Station are being progressed.

Items identified during the 70% design phase that will be further reviewed and documented in the formal SiD process include:

- The limited access when working around FCIC building during construction, including the lifting and placement of spans 2 and 3 under the FCIC building
- The known presence of existing underground services around the piers and abutments
- Lifting and placement of bridge spans
- The provision of safe access for the maintenance and replacement of the roof cladding and drainage systems
- Consideration has been given to the likelihood and consequence of a fire under the walkway emanating from the carpark or service road and the risk has been determined to be low for the following reasons:
  - Low likelihood of a fire at the carpark or roadway beneath the walkway
  - Limited combustible materials present in the structure
  - The open nature of the bridge provides limited opportunity for smoke build-up
  - Open and clear sight lines means that users can identify a fire before choosing to use the walkway
- Provision of a safe pedestrian crossing over the FMC northern access road from the elevated walkway adjacent abutment B.

7.5 Constructability

There is an initial discussion with GSCJV for high-level construction method and work sequence of proposed elevated pedestrian bridge with consideration of site constraints.

7.5.1 Structural

The bridge is to be constructed based on general bottom up construction methodology. Abutments and Pier 1 will be cast in-situ reinforced concrete structures, Pier 2 will be constructed as pre-assembled module and erected on site.

Considering the requirement to minimise the impact of existing FMC traffic, all superstructure will be constructed as pre-assembled modules off site, transported and then installed at the final positions. Precast units with topping slab is being considered for the deck construction, allowing for installation in situ. Temporary traffic control and detour will be required when installing pre-assembled bridge module.

8. Stakeholder Consultation

- Flinders Link - MOM - Alignment Workshop 19/09/17
- Flinders Link - MOM - Architecture Workshop 19/09/17
- Flinders Link - MOM - Pedlink Workshop 20/09/17
- Flinders Link - MOM - Design Presentation Workshop 27/09/17
- Flinders Link - MOM - Weekly Design Meeting 03/10/2017
- Flinders Link - MOM - Weekly Design Management Meeting (GS) 09/10/17
- Flinders Link - MOM - Weekly Design Management Meeting (GS) 16/10/17
- Flinders Link - MOM - Rolling Stock
- Flinders Link - MOM - DPTI Interface Meeting 18/10/19
- Flinders Link - MOM - Flinders University Interface Meeting (20/10/17)
- Flinders Link - MOM - Weekly Design Management Meeting (GS) 23/10/17
- Flinders Link - MOM - DPTI Interface Meeting w/ presentation
- Flinders Link - MOM - Earthing and Bonding 24/10/17
- Flinders Link - MOM - DPTI Interface Meeting 25/10/17
- Flinders Link - MOM - Weekly Design Management Meeting (GS) 30/11/17
- Flinders Link - MOM - DPTI Interface Meeting 01/11/17
- Flinders Link - MOM - DPTI Interface Meeting 08/11/17
- Flinders Link - MOM - Digital Engineering Discussion 14/11/17
- Flinders Link MOM - Digital Engineering Meeting 04/12/17
- Flinders Link - MOM - DPTI Interface Meeting 06/12/2017
- DPTI 30% Design Presentation 12/01/18
- DPTI Workshop 13/2/18
- DPTI Workshop – Wednesday 2nd session – Structures 14/2/2018
- DPTI Electrical Workshop 27/2/18
- DPTI Electrical Workshop 7/3/18
- DPTI Electrical Workshop 20/3/18

Minutes of these meetings and consultations are distributed and are kept within the project's ProjectWise server for record.

A 30% HAZOP workshop was held on 21 November 2017, attended by DPTI, Gateway South representatives and relevant stakeholders and authorities. A subsequent 70% HAZOP workshop was held on 9 March 2018.

9. Operations and Maintenance in design

9.1.1 Cable Trays

150mm (W) cable trays have been provided for Electrical and Communications services (2off total) within the Flinders Elevated Walkway. Due to space/height restrictions within the ceiling space, these cable trays could not be installed ‘top side up’ as this would not allow sufficient room for access to reticulate cabling. To resolve this issue, the cable trays are proposed to be installed ‘upside down’, with cabling supported regularly via suitable Velcro cable ties for the application.

9.1.2 Luminaire Mounting

A vandal resistant luminaire has been proposed. It is proposed for this luminaire to be recessed within the ceiling panel. This will ensure the luminaire is completely concealed and therefore vandalism is expected to be less likely. To ensure access to luminaires/cabling, removable ceiling panels will be provided.

9.1.3 Roof access

The provision of safe access for the maintenance and replacement of the roof cladding and drainage systems will be further considered during the next stage of design. A concealed fixing type systems has been nominated for roof sheeting.

9.1.4 Existing FCIC Building

Access to the existing and future modified sprinkler system to the FCIC building must be maintained after the construction of the elevated walkway. Consideration must be made for access paths for elevated work platforms or similar to enable access to the FCIC soffit.

Sufficient head height clearance over the existing waste water tanks below the elevated walkway must be provided to allow for cleaning.

9.1.5 Bearing access

Access to bearings will be via an elevated work platform.

9.2 Asset Management Register

A preliminary asset register for this design package can be found in Appendix A.

10. Internal Verification

A list of the internal verification reviewers is presented in Table 10-1 with the signed verification records provided in Appendix C.

Table 10-1: Internal Verification

Discipline	Reviewer
Structural design – Independent reviewer	Samir Hanna
Electrical Services – Independent reviewer	Vasili Papageorgiou
Hydraulic Services – Independent reviewer	Paul Lind

11. External Verification

11.1 Independent Design Certifier (IDC)

30% IDC comments can be found in Appendix D.

11.2 DPTI

30% DPTI comments can be found in Appendix E.