APPENDIX E

Structural Report

ST GEORGE HOSPITAL – STAGE 2

CONCEPT DESIGN REPORT – STRUCTURAL

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ST GEORGE HOSPITAL – STAGE 2

CONCEPT DESIGN REPORT – STRUCTURAL

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A	06/08/14	Issued for Inclusion in Project Concept Design Report	TBB	BH	TBB
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Executive Summary

This report outlines the structural engineering requirements of the proposed Stage 2 development works and options for the structural systems for the works covering the following:

- Structural capacity of existing structure and ability to support the loading from the proposed works.
- Structural engineering options for the proposed Acute Services Tower.
- Key structural engineering issues and risks.

This Concept Design Report has been prepared to set the basis for delivery phases of the structural engineering requirements for the proposed redevelopment of the St George Hospital site.

The structural principles and schemes developed during the Concept Design phase of the project specifically address issues including:

- Structural systems to be developed to work within the limitations of the existing structures being built upon and to ensure impact to the operating hospital ED below is avoided or minimised during construction of the Acute Services Tower.
- The new structures will utilise the HI systemised design approach.
- Design in accordance with HI floor vibration requirements.
- Structure to be efficient and make adequate allowance for future flexibility in accordance with HI guidelines.

The proposed structural system for the development is as follows:

- Piled foundation system.
- Either steel or concrete framed building – Options presented in this report to be reviewed in detail with project team to determine preferred solution for the project.
- Shear wall/core lateral system.

The project includes a level of refurbishment and re-use of some of the existing building stock on site. For the works to date analysis and review of the structural requirements for the refurbishment works has been based on the information provided by the St George Hospital Site Investigations & Campus Infrastructure Masterplan (SICIM) works undertaken to date. The SICIM works have generally involved detailed non-invasive investigation of these structures have been undertaken to confirm their suitability for re-use and refurbishment, however it is noted that as is the case with all works on existing structures until construction works are commenced and the existing structure fully exposed there remains a risk of additional structural works being required due to unexpected deterioration or arrangement of existing structure. To minimise this risk ongoing investigation into the existing structure has will be undertaken during the Schematic Design Phase of the works however the risk cannot be eliminated until such time as the structure is completed exposed during construction works.

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1 Introduction

Enstruct group have been engaged by Health Infrastructure NSW as civil and structural engineering consultant on the South Eastern Sydney Local Health District proposed Stage 2 development of the St George Hospital.

This report has been prepared to discuss the Concept Design structural engineering works associated with the hospital redevelopment works for Stage 2.

This report establishes the structural framework for the development outlining the structural design principles for the preferred development option as discussed in this report.

2 Project Overview

These works are the second stage of a masterplan for the overall redevelopment of the St George Hospital campus. The primary works proposed for Stage 2 are as follows:

- New Acute Services Tower to be constructed over the new ED Building.
- Construction of new links between the Acute Services Tower and existing building.
- Partial refurbishment of the existing Tower and CSB.
- Additional parking levels to the existing Gray St multi-storey car park.
- Improvements to the Hospital entry and drop off.
- Demolition of the existing ED building and construction a new Kensington St access and parking.

3 Previous Investigation and Reporting

Detailed site investigations and impacts of the Masterplan works have been undertaken as part of the SICIM works. At this stage of planning works input into the development of the Stage 2 works in regards to the condition and capacity of the existing assets is based upon the Element 1/Element 2/Element 3 reports provided from the SICIM structural consultant Cardno (NSW) Pty Ltd and the geotechnical consultant Coffey Geotechnics Pty Ltd. As the planning phase of the project continues enstruct will undertake further investigations and analysis of the existing structural assets to further develop the information gathered by the SICIM consultants to date.

The following sections are extracted from the SICIM consultant report to provide a summary of their investigations and findings to date.

3.1 Existing Buildings

Figures 1 and 2 are taken from the SICIM Element 3 Structural Report which show a building layout plan and design life/age of structure for the buildings which have been inspected as part of the SICIM works.

The SICIM investigation works found the condition of the existing buildings to vary significantly across the site but generally in good condition with no signs of structural defects or distress evident at the time of inspection by the SICIM structural consultant. The following is a summary of the structural systems for the existing building across the site provided by the SICIM Element 3 Structural Consultant Report.

3.1.1 New ED Building

The New ED building is currently under construction and is expected to be finished late in 2014. This building has been designed as an eight (8) storey building comprising of a Ground Floor, 7 upper levels and a concrete roof. This building is being constructed to Level 1 generally, and up to Level 2 over the plant room area to the north and, office and plant room area to the south. The concrete floors at Level 1 and, Level 2 over the plant and office areas act as roofs and have been provided with a steel framed roof covering for waterproofing.

3.1.2 Gray Street Substation Building

The Gray Street substation building was recently completed as part of the New ED Building Project. The building is of masonry load bearing construction with a concrete roof slab and founded on piles to rock.

3.1.3 New Mental Health Building

The New Mental Health building has been designed for a future vertical expansion to produce a four (4) storey building comprising of a Ground Floor, 3 upper levels and a concrete roof.

The Mental Health building was recently completed to Level 1 with a steel framed roof covering over this concrete level for waterproofing.

3.1.4 Services Building

The services building was recently completed and consists of a two storey structure with a steel framed roof over. The building is not designed for any future expansion.

3.1.5 Gray Street Car Park Building

The Gary Street Car Park is a six (6) storey building with a concrete roof, incorporating 2 basement levels and a helipad on the concrete roof. The structural system for the building comprises of reinforced concrete columns supporting post tensioned concrete slabs. From a walk through visual inspection the car park appears to be in good condition and is generally free of significant defects. Some minor cracking was noted on the slabs and beams but this is non-structural and not unexpected for a structure of this age and type.

3.1.6 Ward Building

The Ward Building consists of the Tower Ward Building (South and West) and the Ward Block. The Ward Building generally consists of concrete frames with masonry infill. The structure as a whole appears to be in good condition for its age and capable of performing its function. A visual inspection of a majority of the facades was completed along with the basement and some typical floors. The structural elements are generally not visible within the buildings, as such, the elements were viewed at discrete locations where visible. The basements gave the best vantage to view and assess the structural assets due to the absence coverings and finishes. Where viewed the structural elements appeared to be in a good condition.

3.1.7 Clinical Services Building

The Clinical Service Building is 3-5 storey centrally stepping structure constructed of reinforced concrete frame and post tensioned slabs. From a visual walk through inspection the structure appears to be in good condition for its age. As with the Ward Blocks, the structural elements were viewed at discrete location or where the structural system could be viewed easily such as basement and stair wells. Some minor cracking to the concrete elements were noted but this is not unexpected for a structure of this age.

3.1.8 Cancer Care Building

The Cancer Care Building is a 2-storey reinforced concrete building with a concrete roof. The concrete roof has an open central plant area and steel framed roof to the perimeter. From a visual inspection the structure appears to be in good condition for its age. The Cancer Care Building has been constructed hard against the Ward Block generally with double columns at the building boundaries.

3.1.9 Current Emergency Building (Kensington Street)

The Current Emergency Building is a concrete framed building with masonry infill. The ED is bounded by Kensington St to the north and the Radiology Building to the remaining boundaries. The condition of the structure is generally good given its age.

3.1.10 Radiology Building

The Radiology Buildings are generally in good condition for their age. The building is bounded by the current ED Building to the north and the CSB building to the south. No original structural drawings of the Radiology Buildings have been located. From visual inspection the buildings appeared to have been constructed over various stages. The main construction type is reinforced concrete frames with masonry infill walls.

3.1.11 Prince William Building

The Prince William building is a three storey concrete framed brick infill structure located north of the Hydrotherapy Building bounded by Belgrave Street and Kensington Street. On the top floor at the northern end of the building a steel framed 'pop up' type structure encloses a gym. The gym structure may not have been part of the original construction. The internal areas to the top floor appeared to have recently been fitted out. The structural elements where viewed appeared to be generally in good condition for their age although the building is now nearing the final stages of its design life. Some cracking to masonry elements was noted generally to the facades.

3.1.12 Hydrotherapy Pool Building

The Hydrotherapy Building is located on the eastern boundary of the campus bounded by the Prince William building to the north and the JMO Facility to the south. The structure consists of a concrete framed building with high ceilings to accommodate the pool. The structural elements appear to be robust (i.e. large columns and beams) for their size and spans. From a visual inspection the structure appeared to be in excellent condition for its age and capable as functioning as designed well into the future.

3.1.13 J.M.O Facility

The JMO Facility is constructed of a demountable type building on isolated brick piers. The structure is generally in a good condition.

3.1.14 Burt Nielsen Wing

The Burt Nielson Wing is a three storey concrete encased steel framed structure enclosed by the Radiology and current Emergency Building. The internal areas of the building were inspected visually at discreet locations and at roof level. The structure appears to be generally in good condition for its age, although it is now approaching the final stages of its design life. During the site investigations it was noted that some of the structural elements (ie columns) differed to that as documented on the existing structural drawings. We note that some of the original perimeter columns, as documented on the existing drawings, could not be located. It would appear that at some stage, structural elements were demolished and the load paths altered to transfer the loads to adjacent structures of the Radiology Building. The steel beams forming the floor structure are coated in what appears to be a fire rating spray such as "Vermiculite".

3.1.15 Existing Mental Health Building

The Existing Mental Health Building is located on South Street bounded by the New Mental Health Building to the west. The building is a two storey concrete and steel framed structure and is generally in an excellent condition for its age.

3.1.16 J.H Laws House

The JH Laws house is a five (5) storey predominately brick structure with a tiled roof located at the southern end of the campus. The building is in a relatively good condition for its age. There are various cracks in the masonry but this is not unexpected for a structure of this construction and age. This building is approaching the end of its design life.

3.1.17 Pitney Building

The Pitney Building is a concrete and masonry framed building located off Chapel Street. The building is in a relatively good condition for its age with typical defects similar to J.H Laws Building. This building is approaching its design life.

3.1.18 Rose Cottage

Rose Cottage is a single storey masonry building of a typical residential type construction. The Cottage is located off Chapel Street on the south east corner of the campus. The Cottage is in good condition for its age.

3.1.19 *Demountable Building 1*

The Demountable building is a stand-alone building which can be demolished or relocated without impact on adjoining buildings.

3.1.20 *Brick Building*

The Brick Building is located in the south east corner of the campus and consists mainly of a single story load bearing masonry structure with a flat roof. Due to the sloping nature of the land in this location the structure has a relatively large sub-floor area. The structure is reaching the end of its design life and this is reflected such in the condition of the façades and fenestrations.

3.1.21 *Banksia House*

The Banksia house is a demountable type stand-alone building which can be demolished or relocated without impact on adjoining buildings.

3.1.22 *Demountable Building 2*

The Research Centre is a demountable type stand-alone building which can be demolished or relocated without impact on adjoining buildings.

3.1.23 *Infill Building and Plant Room*

The infill Building is the structure bounded by the CSB to the north and the Ward Block to the south and east. This structure now houses the Pharmacy and mechanical plant at Ground Level and Medical Records in the basement. The structure consists of reinforced concrete columns and slab with a metal deck roof over the level one slab. A steel framed structure located on the level one slab houses additional mechanical plant. The concrete structure appears to be in good condition for its age with no discernable defects.

BUILDING No. (Refer attached Plan)	BUILDING	CONSTRUCTION TYPE	DESIGN LIFE/AGE
1	New ED Building	Reinforced concrete frame, post tensioned Bondek slabs, supported on piles founded in sandstone. Metal deck roof encloses the top concrete level where future vertical expansion is intended. Currently under construction with further vertical expansion currently under design	50 years/under construction
2	New Mental Health Building	Reinforced concrete frame, conventional post tensioned beam and slab system, supported on pad and piles footing system founded in sandstone. Metal deck roof encloses the top level where future vertical expansion is intended.	50 years/less than 1 year old
3	Services Building	Steel framed structure with concrete/steel composite construction. Metal deck roof cladding.	50 years/1 year old
4	Gray St Car Park	Reinforce concrete frame, conventional post tensioned beam and slab system forms the floors, supported on pad footings founded in sandstone.	Estimated to be 50+ years/ 24 years to date
5	1972 Ward Block	Concrete framed structure with masonry infill walls	Estimated 50 years/Estimated 40+ years to date
6	Tower Ward Block	Concrete framed structure with masonry infill walls	Estimated 50 years/Estimated 23 years to date
7	Clinical Services Building	Concrete framed with post tensioned waffle slabs	Estimated 50 years/23 years to date
8	Cancer Care Building	Conventionally reinforced concrete framed structure	Estimated 50 years/22 years to date
9	Current ED Building	Concrete framed with brick infill	Estimated 50 years/ 19 years to date
10	Radiology Buildings	Concrete framed with brick infill	Estimated 50 years/ 19 years to date
11	Prince William Building	Concrete framed with brick infill	Estimated 50 years/ Estimated 30+ years to date
12	Hydrotherapy Building	Concrete framed with brick infill	Estimated 50 years/Estimated 10+ years
BUILDING No. (Refer attached Plan)	BUILDING	CONSTRUCTION TYPE	DESIGN LIFE/AGE
13	JMO Facility	Steel clad demountable type structure	Estimated 20 years/ 30+ years to date
14	Burt Nielson Wing	Concrete encased steel framed structure with steel/concrete composite floors	Estimated 50 years/Estimated 58 years
15	Existing Mental Health Building	Concrete and steel framed structure with brick infill supported on pad footings founded in sandstone	Estimated 50 years/Estimated 15 years
16	JH Laws House	Brick framed structure	Estimated 50 years/ Estimated 50+ years to date
17	Pitney House	Concrete and brick framed structure	Estimated 50 years/ Estimated 50+ years to date
18	Rose Cottage	Brick framed 'house' structure	Estimated 50 years/ Estimated 50+ years to date
19	Animal House	Steel clad demountable type structure	Estimated 20 years/ Estimated 30+ years to date
20	Brick Building	Predominately a masonry framed building	Estimated 50 years/ Estimated 50+ years to date
21	Banksia House	Steel clad demountable type structure	Estimated 20 years/ Estimated 30+ years to date
22	Infill Building	Conventionally reinforced concrete framed structure	Estimated 50 years/ Estimated 50+ years to date
23	Gray Street Substation	Concrete and reinforced masonry	50 years/less than 1 year old

Figure 1 – Building Design Life/Age from SICIM Element 3 Structural Report

Figure 2 – Existing Building Layout Plan from SICIM Element 3 Structural Report

3.2 Summary of SICIM Consultants Report – Structural

The structural SICIM consultant has assessed and reviewed available structural documentation for the site and undertaken a high level non-invasive inspection of the structural assets across the site. These investigations found the existing buildings across the site to be in general y good condition for their age with the buildings typically having a design life of 50 years. The majority of buildings across the site were found to have a reasonable level of structure life remaining. However buildings that are approaching the end of their design life, although still in good condition for their age, are also approaching the end of their serviceable life.

The majority of the buildings across the site do not have capacity or allowance for vertical expansion without structural strengthening works other than those that have specifically been designed for this allowance, which include the following buildings:

- New ED Building;
- New Mental Health Building;
- Cancer Care Building.

The SICIM structural works have reviewed and commented on the following items of the Stage 2 Expansion works:

- Additional level to the existing Gray St car park building:
  - Report nominates that the additional level can be accommodated by strengthening the existing pad foundations;
- Transfer beams to achieve 8.4m grid in new levels of Acute Services Tower:
  - South West End – Report nominates that to achieve the proposed transfer at Grid 11 post tensioned beams either 1400mm deep at Level 2 or 1300mm deep at Level 3 would be required;
  - North East End – Report nominates that to achieve the proposed cantilever beyond the existing building grid the following options have been investigated:
    - Post tensioned cantilever transfer beams with beam depths nominated as 1500mm at Level 2 and 1400mm at Level 3. The report highlights that the pile capacity at Grid 4 is exceeded with this arrangement;
    - Cantilever floor plate at each level – Grid 4 pile capacity will require review;
    - New footing and column line to the east of Grid 4 – It is nominated that the new piles would clash with the existing contiguous pile wall and in-ground services and likely to also impact on the minimum driveway width;
- Shear walls:
  - The report nominates that the new ED Building structural system had been developed based on the shear walls currently provided through the ED building being extended to the top floor of the new Acute Services tower in conjunction with a new major lift core. With the current planning departing from this approach the report indicates that the structural strategy for the building will require review;
- Effect of new lift core on CSB Building:
  - The report recommends that allowance be made for a 450mm diameter contiguous pile wall with its centreline set 600mm off the face of the CSB Building to ensure that the existing foundations are not impacted;
- MRI Scanner/PET Scanner/CT Scanner:
  - Assessment of the floor capacity to accommodate the loading has not been undertaken with nomination that if the slabs are found to be inadequate steel strengthening beams would be required. The report does confirm that the proposed core holes and set-downs for this equipment can be accommodated with localised structural works;
- New switchroom on Gray St substation building:
  - The report confirms that the proposed new switchroom can be accommodate on the roof of the existing Gray St substation building provided that it is located at the southern end of the building.

3.3 Existing Site Geotechnical Information

The SICIM geotechnical consultant has undertaken both a desktop review and analysis of available geotechnical investigation data available across the site combined with further site boreholes and investigations targeted to areas with lessor levels of existing geotechnical information.

The following is a summary of the information presented in the SICIM geotechnical engineers SICIM report.

3.3.1 Geotechnical Model

The 1:100,000 scale Geological Map of Sydney indicates that the site is underlain by Triassic age Hawkesbury Sandstone. Hawkesbury Sandstone generally consists of medium to coarse grained quartzose sandstone with interbedded mudrocks including siltstone and shale. The sandstone typically weathers to form a relatively thin residual soil comprising clayey sand and sandy clay, whereas siltstone and shale typically weather to form clay and gravelly clay.

3.3.2 Descriptive Soil Model

Superficial Soils:

- Soil Profile:

- o A 1.4m mean thickness of soil is estimated across the site. A somewhat thicker cover appears to prevail in the central part of the Kensington Street elevation, where up to 5m of soil may be found

- Fill:
  - o Fill was encountered in the majority of the boreholes. Including pavement construction, it was rarely found to exceed 1m thick. Whilst the topmost materials included fragments of concrete, possibly brick and ash, the fill was typically described as a mix of clay, sand and gravel. This is possibly derived in part from the underlying Hawkesbury Sandstone. The fill should be regarded as 'uncontrolled'. A cover of fill (interpreted to represent compacted site derived soils) and a slightly deeper weathering profile accounts for moderately deep soils (extend to approximately 3m depth) centrally on the Grey Street elevation. This fill may have been placed to raise a naturally lower area. Such areas that may form shallow and indistinct valleys may be underlain by relatively deep weathered (soil) profiles.

- Residual Soil and Extremely Weathered Material:
  - o Residual soil refers to those that have developed by the in situ weathering of the bedrock, rather than soils that have been subject to mass movement (creep or landslide) or within water (alluvium). Interpretation of the borehole records indicates that soils are almost exclusively residual. The soil is invariable described as stiff or dense (or better). It is apparent that the Hawkesbury Sandstone weathers to form a residual soil that has a dominant cohesive (clayey) behaviour. Whilst the former rock 'structure' has been obscured by weathering, variation in the soils is indicative of the interbedded nature of the parent rock. With depth, increased density and stiffness of the soil and clearer indication of the former rock structure indicates 'extremely weathered material'. A transition between this soil and Class V sandstone and shale (Pells 1998) is often indistinct.

Bedrock:

- Sandstone:
  - o The bedrock is dominated by Hawkesbury Sandstone comprising quartzose sandstone. It is typically medium grained, approximately horizontally bedded, frequently with cross bedded structures. It forms fining upward sequences; beds of siltstone and distinct beds of shale are abruptly overlain by coarser grained sandstone. Induration with iron oxides has created intense staining and can form relatively strong 'bands' within the sequence. Widely spaced sub-vertical joint sets typically persist within the coarser grained rocks.

- Shale:
  - o Shale was observed towards the north and north eastern corner of the campus and extends to 5m or 7m depth in boreholes drilled near to the north and eastern perimeter. Drilling within the shale was possible using auger drilling techniques. It was described variably as hard clay with some indurated materials being recovered as gravel or as very low strength shale that may be interlaminated with sandstone or siltstone. The lower permeability of fine grained units (shale and siltstone) with comparison to the dominant sandstone can represent zones of preferential seepage and build-up of pore water pressure with inherent hazards of instability in cutting slopes for example.

3.3.3 Footing and Pile Design

The following table (Figure 3) is taken from the SICIM Element 2 Geotechnical report and provides a summary of the recommended footing design parameters across the site.

Geotechnical Unit (1)	Serviceability End Bearing Pressure (2) (4) (MPa)	Ultimate End Bearing Pressure (2) (MPa)	Ultimate shaft Adhesion (3) (5) (kPa)	Elastic Modulus (4) (MPa)
Sandstone (Class V)	1	3	150	75
Sandstone (Class IV) Assumes penetration of Class V Sandstone	3.5	10	500	300
Sandstone (Class III or better)	6	30	1200	1000

(1) Rock classified in accordance with Pells et al (1998) "Foundations on Sandstone and Shale in the Sydney Region" Aust. Geomech. Jnl, Dec 1998.
(2) Assumes a minimum embedment of at least 0.3m into the relevant bearing stratum.
(3) Assumes a minimum embedment of at least 2 pile diameters into rock.
(4) Serviceability end bearing pressures quoted above are based on a footing settlement within 1% of the footing width as suggested by Pells et al (1998). Serviceability should be assessed using the modulus value to check that settlements are within tolerable limits.
(5) Shaft adhesion should be ignored for pad footings.

Figure 3 – Recommended Footing Design Parameters from SICIM Element 2 Geotechnical Report

3.3.4 Groundwater

Groundwater was not encountered during augering in soil and weathered rock. Water was used as a drilling fluid during core drilling which prevented subsequent groundwater observations. Following drilling, standpipe piezometers were installed in BH401, BH405 and BH408. The standing water depth in these boreholes was found to vary between 2.1m and 4.0m below ground level.

3.3.5 Risks

The following perceived geotechnical risks are associated with the delivery of all stages of the Masterplan:

- Rock excavatability;
- Instability of excavations and excavation induced ground movements;
- Damage to adjacent structures due to excavation induced vibrations;
- Unforeseen ground conditions;
- Future design changes resulting in insufficient geotechnical information.

4 Structural Engineering Concept Design Principles

The new structures will utilise the HI systemised design approach.

4.1 Design Standards

The structural design shall be in accordance with the latest revision of all relevant structural Australian Standards, relevant structural sections of the BCA and other statutory requirements.

In particular the structural design will be in accordance with the following relevant Australian Standards:

- AS/NZS 1170.0 (2002) – Structural Design Actions Part 0 General Principles
- AS/NZS 1170.1 (2002) – Structural Design Actions Part 1 Permanent, Imposed and Other Actions
- AS/NZS 1170.2 (2011) – Structural Design Actions Part 2 Wind Loads
- AS 1170.4 (2007) – Structural Design Actions Part 4 Earthquake Actions in Australia
- AS 2159 (2009) – Piling – Design and Installation
- AS 2670.1 (2001) – Evaluation of Human Exposure to Whole-Body Vibration – General Requirements
- AS 2670.2 (1990) – Evaluation of Human Exposure to Whole-Body Vibration – Continuous and Shock-Induced Vibration in Buildings (1 to 80Hz)
- AS 3600 (2009) – Concrete Structures
- AS 3700 (2011) – Masonry Code
- AS 4100(1998) – Steel Structures
- AS 4678 (2002) – Earth Retaining Structures

4.2 Design Life

The building structure will be designed to provide adequate performance for a minimum period of 50 years with a typical structural maintenance system.

4.3 Materials

The following structural materials are proposed to be used in the works. Typical values for the properties of these materials are listed. These values are to be adjusted where appropriate.

4.3.1 Concrete

4.3.1.1 Properties

Co-efficient of thermal expansion	$12x10^{-6}$ per ^{0}C
Basic shrinkage strain	In accordance with AS 3600 Clause 3.1.7
Basic creep factor	In accordance with AS 3600 Clause 3.1.8
Poisson's ratio	0.2
Density	24 kN/m^3

4.3.1.2 Proposed Concrete Grades

Footings	40MPa
Suspended Slabs and Beam	40MPa
Columns	40 to 50MPa
Walls	40 to 50MPa
Other areas (UNO)	40MPa

4.3.2 Reinforcement

4.3.2.1 Properties

Plain bars (R)	fsy = 250 MPa
Deformed bars (N)	fsy = 500 MPa
Welded wire fabric (L)	fsy = 500 MPa
Young's modulus	200 x 10^3 MPa

4.3.3 Structural steel

4.3.3.1 Properties

Grade (UNO)	300MPa
Steelwork density:	7850 kg/m^3
Young's modulus:	2.05 x 10^5 MPa
Poisson's ratio:	0.3
Coefficient of thermal expansion:	12 x 10^{-6}

4.3.4 Blockwork

4.3.4.1 Properties

Characteristic Strength	15 MPa.	
Mortar mix (cement:lime:sand)	1 : 1 : 6	Unreinforced Blockwork
	1 :0.5: 4.5	Reinforced Blockwork
Core fill grout	20 MPa	

4.4 Loading

4.4.1 Vertical

- Typical Floor Areas:
  - SDL = 1.8kPa (excluding sacrificial topping);
  - LL = 3.0kPa;
- Plantrooms:
  - SDL = 2.5kPa;
  - LL = 7.5kPa;
- Stairs:
  - SDL = 0kPa;
  - LL = 4.0kPa;
- Toilets/Bathrooms/Kitchens:
  - SDL = 1.8kPa (excluding sacrificial topping);
  - LL = 2.0kPa;
- Non-Trafficable Metal Deck Roof Areas:
  - SDL = 0.5kPa;
  - LL = 0.25kPa;
- Trafficable Concrete Roof Areas:
  - SDL = 2.5kPa;
  - LL = 4.0kPa;
- Car Parking:
  - SDL = 0kPa;
  - LL = 2.5kPa
- Helipad:
  - SDL = 1.0kPa;
  - LL = 5.0kPa.

4.4.2 Wind

Wind loading is in accordance with AS/NZS 1170.2 – Structural Design Actions – Wind Actions with the following parameters:

- Annual probability of exceedance – 1:2000;
- Region A2;
- V_{2000} – 48m/s;
- Terrain Category TC3.0.

4.4.3 Robustness

Robustness loading in accordance with AS/NZS 1170.0 – Structural Design Actions General Principles with the following parameters:

- 1.0% of (G + ψ_cQ) load case;

4.4.4 Earthquake

Earthquake loading in accordance with AS 1170.4 – Structural Design Actions – Earthquake Actions for Australia with the following parameters:

- Annual probability of exceedance – 1:1500;
- k_p = 1.5;
- Z = 0.08;
- Class B_e;
- Earthquake Design Category III;
- Dynamic Analysis.

4.5 Serviceability

4.5.1 Deflection limits

4.5.1.1 Vertical

Maximum vertical deflections shall be in accordance with Table 2.3.2 of AS 3600 – 2009.

4.5.1.2 Lateral

The lateral drift of the building will be limited to the following:

- Under Serviceability Wind Actions – Height/500
- Under Earthquake Actions (AS 1170.4 clause 7.5) – Height/67

4.5.2 Floor Vibrations

The design of the floor structure will ensure that vibration due to footfall excitation is kept within acceptable limits. These limits will be based on Health Infrastructure Design Guidance Note 1 – Structural Design Criteria Guidelines (refer Appendix A) and the recommendations of AS 2670.2 adjusted for the intended occupancy and approximate duration of vibration. The vibration design parameters for the project will be as follows:

Area	Damping	Footfall Frequency (Hz)	Sacrificial Topping Considered Structurally	Response Factor
Clinical Areas	2.5%	2.1Hz Typically 2.5Hz Corridors	Yes	2
Operating Theatres/ Imaging Areas/ Procedural Areas	2.5%	2.1Hz	Yes	1
Plantrooms and External Areas	Not Considered			

A structural solution for minimising the structural floor plate system in areas required RF=1 performance if the provision of steel serviceability posts connecting the floor to either the adjacent floor above or below to mobilise additional mass and stiffness to achieve the RF=1 performance. This is expected to allow the entire concrete floor plate to be designed for RF=2 with the steel serviceability posts increasing vibration performance in the areas required without structural slab depth and cost penalty and providing full future flexibility for operating theatre relocation.

HI, ERG and the project team have accepted the approach of achieving RF=1 in vibration sensitive areas allowing all floor plates to be designed for RF=2 vibration characteristics with steel serviceability posts added to achieve RF=1 in vibration sensitive areas. This will achieve structural optimization and cost savings in the vibration sensitive areas of the building.

All equipment which may be a possible source of vibration will be isolated from the structure through the provision of isolation mounts.

4.6 Fire resistance levels for structural elements

Fire resistance levels for structural elements will be in accordance with the structural requirements of the BCA and will developed with the project BCA consultant. Design of individual structural elements to achieve the required FRL will be in accordance with the appropriate materials design code.

For a steel framed floor plate option an alternate solution would be investigated for the fire rating of the floor plate. Detailed analysis and co-ordination between the structural engineer, fire engineer and BCA consultant will be required to determine minimum fire rating requirements of the floor plate which if the steel floor plate system is selected will occur during the future phases of the project. Initial advice from the fire engineer has outlined the following fire rating requirements for a steel framed floor plate:

- All primary beams to be fire rated;
- All secondary beams on grid to be fire rated;
- All secondary beams in bays with either a fire or smoke wall to be fire rated;
- All columns to be fire rated.

4.7 Foundations

Based on the foundation design provided for the new ED Building and the SICIM geotechnical investigation works it is expected that the foundation system for new structure requiring new foundations will be bored piles founding on Class III sandstone with a length of approximately 5-6m.

As the majority of new foundation works will be undertaken within the infill area to the east of the new ED building which does not have direct vehicular access detailed consideration of the construability of the foundation systems will need to be undertaken to ensure that the equipment required to construct the foundations can readily access the works zone. Investigations with piling contractors have identified the following options for the construction of the piles in the infill area:

- Limited access rig which could drill piles up to 600mm diameter to the depth required (approx. 5m) has dimensions in the order of 1.8m wide x 4m long x 3m high, with the height able to be reduced to 2.2m when bringing the machine onto site with partial disassembly of the machine and then reassembly once in place which is not common but can be done;
- Limited access rig which could drill piles up to 750mm diameter to the depth required (approx. 5m) has dimensions in the order of 2.2m wide x 4m long x 3m high, with the height able to be reduced to 2.2m when bringing the machine onto site with partial disassembly of the machine and then reassembly once in place which is not common but can be done;
- Standard pile rig to drill the preferred piles if access was not an issue, ie 900/1050/1200mm diameter piles, is around 33 tonnes. Which does not appear to be able to be craned over the ED building based on a review of the typical cranes available in the Sydney region with the largest crane could lift of approximately 12t for the required 50m reach to get the rig over the ED building, ie this piling rig does not appear to be able to be craned into position.

For each of the limited access piling rig options modifications to the link between the existing hospital and the new ED Building will need to be undertaken to allow access for the piling rig.

Further assessment and review of the foundation systems for the project will be undertaken with key members of the project team (ie project manager, cost consultant and geotechnical engineer) during continuation and completion of the Schematic Design Phase of the project to ensure that foundation systems and costs are minimised.

4.8 Retaining Walls

Based on the current planning the only areas expected to require site retention is the base of the new core in the infill area to accommodate the lift overruns. Due to the space constraints and adjacency of existing buildings a piled retention system will be developed for this area. As per the foundations detailed constructability of the retention piles will need to be undertaken to ensure that the required equipment can access the works area.

At this planning stage of the project a minimum structural allowance of 600mm should be provided for the construction of the site retention system around the lift pit of the main core – Refer to sketch in Appendix C for conceptual structural arrangement of the site retention and foundations in this area.

4.9 Movement Joint

The new ED building has a permanent movement joint located adjacent to Grid 10 to allow for long term creep and shrinkage shortening of the floor plate. The permanent movement joint requires two separate lateral systems to be provided for the north and south portions of the building. In addition, clinical planning needs to develop a layout which allows a permanent joint at this location.

enstruct has undertaken preliminary analysis for the need to continue the provision of the permanent movement joint on the upper floors of the ED tower.

Following this review it is proposed for the concrete framed floor plate system to replace the permanent joint with a temporary movement joint which will allow the required movement when the floor plates are first cast and then this joint will be grouted (after 98 days) to knit the structure permanently. For a steel framed floor plate system due to the continuous layer of slab reinforcing which will provide a level of crack control beyond that of a post tensioned slab the movement joint is proposed to be deleted.

For the option of either conversion of the permanent movement joint to a temporary movement joint or the deletion of the joint entirely the primary benefit of this approach is that it will reduce the lateral structure requirement of the new tower to a single system.

4.10 Lateral System

Wind, robustness and earthquake loading have been considered for the lateral structure of the building. Due to the building height and geometric plan arrangement of the building, the critical action for the lateral design of the building is due to earthquake.

A preliminary lateral analysis of the building has been undertaken to determine the required elements for the lateral system:

- New lift core to the east of the building – This new core will be constructed of cast in-situ concrete walls founded on new piled foundations;
- Existing stair shaft to the south –This existing stair shaft formed part of the lateral system proposed for the tower extension in the design and documentation of the new ED building which indicates that the core is able to accommodate a portion of lateral loading. We are currently awaiting a loading diagram from the new ED Building engineer which will confirm the lateral load that can be accommodated by this core. This core is concurrently being reviewed by enstruct to confirm lateral capacity of the existing core. Subject to determination of the ratio of the applied load to the capacity of this core, other lateral elements may need to be strengthened to limit the load applied to this existing core. Alternatively, some strengthening works to the core could be undertaken. The structural direction for this existing core will be based on the findings from above;
- New stair shaft to the north of the building – This new core will be constructed of cast in-situ concrete walls founded on new piled foundations;

Refer to the sketches provided in Appendix D for concept details of the building lateral system.

4.11 Vertical Structure

All columns for the primary building structure will be construction from either reinforced concrete for concrete framed floor plates or steel columns for a steel framed floor plate. The columns for lightweight structures (i.e. plantroom roofs etc.) will be steel columns.

4.12 Column Grid

In accordance with HI Design Guidance Note 1 – Structural Design Criteria Guidelines the column grid across the project will be 8.4m x 8.4m at all locations possible. The new ED Building below has several column set off grid to accommodate planning requirements. Investigation of transfer options for these columns has commenced structurally (as outlined below) and will be progressed in further detail in the Schematic Design phase with the project team to determine the columns which are to be transferred.

4.13 Suspended Floor Plate

At all areas possible the HI systemised design approach of an 8.4m x 8.4m grid will look to be implemented. However with areas of the new ED building varying from this grid, transfer structures will need to be provided or the existing ED Building grid retained, this is to be further developed with all members of the project team.

The design of the floor plates will be in accordance with the HI Structural Design Guidance Note to ensure that vibration requirements are satisfied and future flexibility is provided for through the provision of future penetration zones adjacent to internal columns and an integral non-structural screed to allow for future set-downs.

Several floor plate systems are being analysed for consideration in the development of the planning for the project. These options include the following:

- Post tensioned band beams with a one way slab;
- Post tensioned concrete flat plate with drop panels at columns;
- Steel framed floor system, with both conventional downstand composite and a system with the steel beams within the depth of the concrete to be developed;

Preliminary details of these options are included in Appendix B of the report and will be further developed and refined through the Schematic Design phase.

Cost and program analysis of the concrete and steel floor plate options are being undertaken by the project QS and programmer to allow comparison of the structural systems. Further to this a qualitative comparison of the concrete and steel floor plate systems has been undertaken and is presented in Appendix E.

These systems will be reviewed with the project team taking into detailed consideration the ability of each floor plate system to satisfy the key requirements: (a) remaining within the vertical structural capacity of the new ED Building below, (b) services reticulation, (c) site access requirements, and (d) construction impacts to adjacent operating ED (described below).

The Level 2 floor plate of the ED building has been constructed with post tensioned beams designed to accommodate the construction stage loading of a concrete floor plate above. However it must be noted that the slabs have not been designed with such a provision. Therefore, if a concrete floor plate system is selected; temporary steel propping will need to be provided between the primary beams to support the slab above. Furthermore, it must also be noted that a self-supporting system such as a steel framed system will not require this temporary propping.

It is proposed that floor plates be designed to achieve vibration performance of response factor of either 1.0 or 2.0 (RF=1.0 to be achieved through the addition of steel serviceability posts to a RF=2.0 floor plate) as outlined above, which aligns with current HI guidelines for structural systems. Options for strengthening at areas requiring increased vibration performance via serviceability posts connecting to vertically adjacent floor plates to mobilise increased stiffness and mass to improve vibration performance have been investigated and will be developed further during the continuation and completion of the Schematic Design Phase of the project. Areas which will require increased vibration performance are those which either house sensitive equipment, ie areas medical imaging and areas in which invasive procedures are undertaken, ie operating theatres.

Floor plates will be designed to accommodate an integral 50mm non-structural screed throughout.

Floor plate will be designed to allow for future penetrations to maintain the future flexibility of the structure in accordance with Health Infrastructure Design Guidance Note 1 – Structural Design Criteria Guidelines.

Movement joints will be required where the new and existing facilities interconnect and these will need to allow for earthquake framing movements.

4.14 Non-Structural Screed

A non-structural zone of 50mm is to be provided on all suspended floor plates (excluding plant areas) in accordance with the Health Infrastructure Design Guidance Note 1 – Structural Design Criteria Guidelines. This non-structural screed is to be cast integrally with the structural slab to avoid having a second concrete pour and finish with a post applied screed, resulting in program and cost benefits for the project. To accommodate the integral non-structural zone the top cover to all reinforcing and post tensioning will be set at 70mm to ensure that in locations were the non-structural zone is removed 20mm cover (code minimum) is maintained. To allow the removal of the integral non-structural zone in the future saw cutting at close centres will be required to ensure that removal of the zone does not extend past the 50mm allowed zone;

4.15 Lifts and Stairs

Internal stair shafts and lift shafts will be constructed from either precast or in-situ reinforced concrete walls, expected to range between approximately 200mm to 300mm thick.

All stairs will be constructed from reinforced concrete with the construction methodology to be either cast in-situ, stairmaster (or similar light gauge steel form system) or precast.

4.16 Roof Structure

Roof structure over any exposed concrete slabs will be a light weight steel roof over fixed off the concrete slab with the steel roof cladding providing water tightness.

All other roof structures such as plantrooms and the like will be portal type steel framed structures supported off the 4 concrete slab below clad with lightweight cladding.

4.17 Vertical Transfer Structure

4.17.1 North East Corner

Two planning options have been developed for the cantilever of the floor plate in the north east corner of the building.

Option 1

Option 1 planning proposes a cantilever of the floor plate beyond the ED Building column grid in the north east corner. This cantilever can be achieved:

- Deep post tensioned floor beams on grid;
- Deep steel framed floor beams on grid;
- Full height steel framed transfer truss on grid;
- Floor by floor cantilever beams – To minimize building weight and structural depth on all floors this option has not been investigated further;
- Provision of new column grid to the east of the existing building – Due to planning limitations this option is not feasible and has not been investigate further.

A selection of the above options have been developed to a preliminary level of detail to allow the full project team to review and compare these transfer options. Details of the systems developed are presented in Appendix F.

Option 2

Option 2 planning reduces the cantilever of the floor plate to a maximum of 2100mm which can be achieved on a floor by floor cantilever arrangement. These cantilevers are provided on both the eastern and western side of the floor plate to achieve the required building footprint.

The structural framing requirements for the Option 2 arrangement are presented in Appendix G.

4.17.2 Zone Above Ambulance Bay

Due to the planning requirements of the ambulance bay a number of columns in the new ED building are located off grid. If these columns are required to be provided on grid two structural options to achieve this have been investigated to a preliminary level of detail:

- Deep post tensioned floor beams on grid;
- Full height steel framed transfer truss on grid.

The structural framing requirements for each of these options is presented in Appendix H.

4.18 Capacity of new ED Building Columns and Foundations

It has been advised by Cardno (structural consultant for the ED Building and SICIM works) that the As-Built structure for the new ED building can accommodate the vertical loading (based on a concrete framed building) of the proposed Acute Services Tower with the exception of the piles supporting the proposed cantilever in the north east corner. A loading diagram is has recently been prepared by Cardno to formally convey this advice and is included in Appendix I, further detail and clarification of this loading diagram is required and is currently being sought from Cardno.

enstruct has undertaken a review of loading for the new tower against the calculated capacity of the documented ED building structure and found the following:

- Concrete Frame:
  - Columns excluding those adjacent to Grid E in the north east corner of the building:
    - Concrete columns have sufficient capacity;
    - Piles have sufficient capacity based on the capacity nominated in the piling contractors design.
  - Columns adjacent to Grid E in the north east corner:
    - Option 1:
      - Concrete columns are approximately 20% overstressed with the nominated concrete strength of 50MPa. Concrete test information for these columns has been provided by the ED Building contractor showing a minimum concrete strength of 57MPa was achieved for these columns reducing this level of overstress to 15%;
      - Piles are a combination of 1050mm and 750mm diameter piles with the 1050mm piles having sufficient capacity and the 750mm piles being approximately 11% overstressed (based on piling contractor's capacity nominated in design submission and the inclusion of the Helipad load).
    - Option 2:
      - Concrete columns are approximately 3% overstressed with the nominated concrete strength of 50MPa. Concrete test information for these columns has been provided by the ED Building contractor showing a minimum concrete strength of 57MPa was achieved which provides these columns with sufficient structural capacity for the Option 2 layout;
      - Piles have sufficient capacity based on the capacity nominated in the piling contractors design.
- Steel Frame:
  - Columns excluding those adjacent to Grid E in the north east corner of the building:
    - Concrete columns have sufficient capacity;
    - Piles have sufficient capacity based on the capacity nominated in the piling contractors design;
  - Columns adjacent to Grid E in the north east corner:
    - Concrete columns have sufficient capacity;
    - Piles have sufficient capacity based on the capacity nominated in the piling contractors design.

4.19 Gray St Car Park Structure

The redevelopment works propose to relocate the helipad and convert this floor area to car parking and construct a new slab level above for additional car parking.

Based on the new slab being constructed as a composite steel framed system with a 120mm thick slab supported on metal decking a preliminary review of the existing building structure has found the following:

- Based on strut and tie analysis we have determined that the reinforcement in Pad Footings (Type A and B) has sufficient capacity for the proposed redevelopment works and the resultant increased loads. The bearing capacity of the soil is exceeded by the load in pad footings by up to 10% but this is expected to be allowable based on further geotechnical investigation.
- Existing columns are structurally adequate for the revised loading arrangement;
- The existing lateral structure will require strengthening to accommodate the increased lateral load on the building and bring the lateral system into conformance with current structural codes of practice. This lateral strengthening is likely to be best constructed as either new concrete blade walls or steel cross bracing between columns, with the details to be developed as planning progresses for review with project team.

4.20 Green Star

Structural influence on Green Star targets for a building of this nature is limited to the following criteria:

- Mat-5 Concrete;
- Mat-6 Steel.

The points targeted for these items should be those which have nil or negligible impact on the project structural cost. Outlined below are the points that we would recommend be targeted for the project with nil or minimal cost impact on the project.

4.20.1 Mat-5 Concrete

Given the location of the project and size of local concrete suppliers it is expected that the existing local concrete plants would have the bin and silo arrangement required to readily accommodate the use of supplementary materials for the binder and replacement recycled products for the concrete aggregates. On this basis we would recommend that 2 Green Star points be targeted for the Mat-5 Concrete credit, with one point for cement replacement and one point for aggregate replacement.

4.20.2 Mat-6 Steel

For a building of this nature we would recommend that 1 Green Star point be targeted for the Mat-6 Steel credit by requiring the following of the reinforcing used in the project;

- At least 95% of reinforcing is sourced from a responsible steel maker;
- At least 95% of all reinforcing bar and mesh meets or exceeds 500MPa strength grade, and at least 60% of all reinforcing steel is produced using energy-reducing processes in its manufacture.

4.21 Links between New and Existing Structures

Connections will be required between the new and existing structures. These links will be designed to be either connected to the new building structure or free standing subject to development of the planning for these links, with either arrangements the link structures will be independent of the existing building structure to ensure that there is no modification to the existing structural loading and arrangement. As the link will be independent of the existing building a movement joint will be provided at the junction between the new link structure and the existing building structure. The movement joint will be detailed to accommodate all building movements, ie wind and earthquake loading, for both serviceability and ultimate limit state loading conditions.

The location of the link connection to the existing structure will need to avoid existing steel/concrete columns supporting the existing roof structure to ensure that modification works to the existing building structure can be avoided with the works to the existing building limited to the creation of an opening to allow for the link between the buildings.

4.22 Refurbishment Works

The majority of the refurbishment works do not involve modification to the building structure with the exception of the main entry refurbishment works and the installation of a new MRI in the existing building.

4.22.1 Main Entry Refurbishment Works

The structural works associated with the main entry refurbishment is the construction of a new interfloor stair in the vicinity of the existing main tower block lift core. This new stair will require the construction of a new opening in the floor plate which will require structural strengthening. To allow the construction of the new opening a grillage of steel underpinning beams connected to the existing building columns will be provided to provide vertical support to the new slab opening and stair.

The new interfloor stair structurally can be either steel or concrete framed.

4.22.2 New MRI in Existing Building

It is proposed to install a new MRI unit in the existing radiology unit of the hospital on Level 1 – Refer to sketch in Appendix J for details of proposed Option 1 & 2.

The following items are relevant to both installation options:

- No existing structural drawings of the buildings in which the proposed installation option 1 and 2 have been provided by the SICIM investigation works or through our searches to date. We will continue to try an locate structural drawings for these building however detailed structural surveys of these areas are likely to be required to determine structural systems in these areas;
- Structurally the largest item for consideration is the magnet which has a weight of 11.8 tonnes. Using the footprint of the magnet this weight is equivalent to a uniformly distributed load (UDL) of approximately 24kPa. As the floors in the area of installation are concrete framed some allowance for increase in footprint can be considered to reduce the UDL, based on typically structurally allowances a 1m increase in the support area on all sides is likely to be achievable however this will need to be reviewed in detail once structural details of the supporting floors are known, with a 1m increase in support area around the perimeter of the magnet the UDL reduces to 7kPa;

- As the structural drawings for these buildings are not available the exact floor loading allowances are not known. However based on experience with health facilities of this nature and code requirements the floors in the proposed area of installation are likely to have a UDL live load capacity of 3-4kPa which is less than the loading from the magnet;
- To accommodate the magnet strengthening of the floor is likely to be required. This strengthening will be in the form of additional beams below the slab connected to adjacent columns to increase the capacity of the floor. Due to the limitation in steel allowances below the MRI unit nominated by the manufacturer (ranging from 0kg/m2 from 0-76mm below the top of the slab to 39.2kg/m2 up to 330mm below the top of the slab) these strengthening beams may need to be constructed from concrete rather than steel – Further information from the manufacturer will need to be sought once detailed investigations commence to confirm;
- The limitations of structural steelwork below the MRI unit are as low as 0kg/m2 from the top of the slab to 76mm below the top of the slab, this is likely to be exceeded as it is expected that some level of top reinforcing will have been provided in the slab which although will have a low kg/m2 weight it will exceed 0 – Further details will be required from the manufacturer as to what can be accommodated as 0 will not be possible with the existing slab unless a 50-75mm topping is provided to the floor;
- The manufacturer requirements nominate that a maximum floor deviation of 3mm from high to low point is allowable, it is expected that the floor will exceed this so topping and levelling of the floor is expected to be required;
- The manufacturer requirements nominate that a response factor of 0.15 is to be achieved in the magnet room for the MRI. This is a stringent vibration performance requirement that is unlikely to be achieved by the existing floor plate and will need to be considered in determination of the floor strengthening to ensure that this is achieved by the strengthened floor.

Items specific to each option are as follows:

- Option 1:
  - As installation is expected to be through the external wall of the MRI room local demolition of the external façade will be required and no floor strengthening for the delivery route will be needed other than the general floor strengthening for the magnet room;
  - The magnet room will need to be strengthened as outlined above to achieve the loading and vibration performance requirements of the unit;
- Option 2:
  - The proposed delivery route of the unit is through an area that is expected to have a live load capacity of 3-4kPa which is less than the UDL weight of the magnet. To accommodate the delivery the slab in this area will need to be backpropped to the floor below (ground floor) during delivery of the magnet;
  - The magnet room will need to be strengthened as outlined above to achieve the loading and vibration performance requirements of the unit.

4.23 Enabling Works

4.23.1 SICIM Project Provisional Enabling Works

The SICIM project have provided the following provisional list of structural enabling works (heading taken from SICIM consultants report):

- New ED Roof:
  - The roof over the new ED Building requires removal (this is a steel framed and metal clad roof structure) to allow construction of the new tower to be undertaken;
  - To minimise the time in which the roof of the ED is exposed to the weather it is proposed that the removal of this roof is undertaken by the main works contractor just prior to commencement of the building structure for the new tower. The proposed system for this is to provide waterproofing to the areas susceptible to leakage, ie joint between existing ED roof slab and façade, movement joint and services penetrations;
- Kensington Development:
  - Remove bollards and other minor structures and prepare for site access;
  - To provide an increase in site car parking it is proposed that the existing ED department being vacated is demolished as part of the enabling works to allow the construction of a new entry to the hospital and the provision of additional car parking;
- Service Plant Structure:
  - Structure to house plant eg substation;
  - With the construction of the new substation to be undertaken as part of the main works these works will be undertaken by the main works contractor;
- Infill Building:
  - Remove cladding and fixtures (internal and external) in preparation for partial demolition;

- To maintain weather tightness of this building the cladding removal of buildings impacted by the new works in the infill area is proposed to be undertaken by the main works contractor immediately prior to structural works commencing in this area;
- Demountable Building:
  - Remove Demountable building;
  - All unused/surplus demountable buildings should be removed from site to maximise the site area available to the main works contractor on what is a constricted site;
- Gray St Car Park:
  - Footing strengthening in preparation for vertical expansion of the car park;
  - As the construction of the new car parking levels cannot occur until such time as the new tower is completed and the helipad is relocated to rooftop of the new tower it is proposed for the foundation and lateral strengthening works to be undertaken in conjunction with the extension of the car parking levels by a single contractor;
- Kensington St Development:
  - Disconnect awning from Prince William Façade;
  - To provide an increase in site car parking it is proposed that the existing ED department being vacated is demolished as part of the enabling works to allow the construction of a new entry to the hospital and the provision of additional car parking.

4.23.2 Proposed Structural Enabling Works

The following outlines the proposed enabling works to be undertaken which relate to structure:

- Demolition of the existing ED Building on Kensington St:
  - To provide an increase in site car parking it is proposed that the existing ED department being vacated is demolished as part of the enabling works to allow the construction of a new entry to the hospital and the provision of additional car parking. The SICIM structural consultant report and investigations have found that the existing ED building is independent of the adjacent building with separate structures provided for the adjacent building nominating "*the demolition of the current ED building will not have any significant structural implications on The Radiology (II) building;*"
- Modification of the Access way through the New ED Building and Existing Hospital Link:
  - As the doorways in the link between the new ED Building and the existing hospital are less than the size of the piling rig that will be needed in this area it is proposed to increase the size of the doorways across this link as part of the enabling works. It is understood that the ceiling height in this link has been investigated by others and confirmed to achieve the required clearance of 2.4m;
- Main Core Lift Overrun:
  - As the lift overrun requires site retention prior to excavation of the pit it is proposed that the piled retention system be constructed as part of the enabling works. The construction of the retention system will allow the main works contractor to commence excavation of the lift/core bases immediately upon establishment on site. Excavation of the lift/core bases was consider for an enabling works package however to remove the risks associated with an open excavation for a possible long duration these excavation works have been left in the main works package.

5 Key Delivery, Staging and Procurement Issues

5.1 Interface Issues with Existing Structure

The development of the relationship between the new and existing structures will need to ensure that construction activities can be effectively undertaken without cost or program penalty while ensuring that the existing hospital continues to function without impact to services. Key structural items for consideration are as follows:

- Design of structural systems that can be constructed using conventional techniques immediately above a functioning ED;
- Provision of sufficient separation between new and existing structures to ensure that noise and vibration generated by the construction works is controlled to an acceptable level within the existing hospital areas;
- Arrangement of new works or phasing of works must ensure that unencumbered ambulance access to the hospital is maintained at all stages of works;
- Development of layout for new works ensuring that materials handling and staging areas can be readily provided adjacent to the works area in a location that is removed from the existing hospital operations to allow the contractor to operate independently of the existing hospital. This layout also needs to consider material handling requirements ensuring that the number of cranes and alimak is minimized without impacting on construction efficiencies.

All new structures will be designed to be supported independently of existing structures ensuring that all new works are compliant with current code and legislative requirements which avoids the potential need to provide upgrading to existing structures that do not comply with current code requirements to achieve building certification.

Movement joints will be provided between all existing and new structural interfaces with these joints designed to ensure that all required strength is maintained under ultimate loading conditions (movement in rare and major structural loading events, ie earthquake) and that the joint and surrounding non-structural elements remain serviceable during serviceability events (movement that is expected to occur on numerous occasions throughout the building life, ie 20 year return period wind loading), these movements will be clearly nominated on the structural drawings to ensure that all members of the design team are able to incorporate into their relevant design elements.

5.2 Staging and Constructability Issues

Key structural staging issues are as follows:

- Ensuring that packages of works can be completed within single mobilisations and as one construction activity – It is expected that the project will be split into enabling works packages, main works and then refurbishment works.
- Provision of sufficient horizontal clearance between new and existing works to allow efficient construction – New buildings can be built abutting existing structures with a project cost and program penalty;
- Provision of suitable site access and site staging areas – To allow for efficient construction of main works suitable access and site staging areas should be provided via a combination of consideration of these requirements during development of building layout for this phase of development and implementation of appropriate enabling works to provide clear site access and staging areas once main works commence, for the constricted nature of the site efficient planning and development of the site access strategy will need to be a focus of all members of the project team.

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6 Risk Assessment

The key risks in relation to structure for the redevelopment are identified in the table below:

Consequence rating: C1=catastrophic, C2=major, C3=moderate, C4=minor, C5=minimal
Likelihood rating: L1=almost certain, L2=likely, L3=possible, L4=unlikely, L5=rare

Identification				Category		Analysis			Risk Rating 1			Treatment		Risk Rating 2		
Risk ID	Risk Name	ID'd by	Status	Risk Owner	Category	Cause(s)	Effect / Consequence	Existing Controls	C	L	Risk Rating	List further tasks required to reduce risk to acceptable level	Due date	C	L	Risk Rating
	Risk Item Subject	Company Initials	Open or Closed	Company Initials	Risk Category	Short Description	Short Description	Short Description	Consequence Rating - Refer Matrix Tab e.g. C5	Likelihood Rating - Refer Matrix Tab e.g.. L3	Overall Rating - Refer Matrix Tab - e.g.. A, B, C...etc.	Short Description	Date	Consequence Rating - Refer Matrix Tab e.g. C5	Likelihood Rating - Refer Matrix Tab e.g.. L3	Overall Rating - Refer Matrix Tab e.g.. A, B, C...
CIVIL & STRUCTURAL																
CS01	New ED building vertical and lateral structure has inufficient capacity to support building weight of required building for the new works over	enstruct	Open	enstruct	Design/ Technical	Vertical and lateral capacity of ED building limited to that designed for New ED works	Possible limitation of size of new development works that can be accommodated above existing ED Building	New ED consultants made some allowance for vertical expansion, however this may not match proposed works. SICIM consultants have reviewed capacity of building and confirmed proposed works can be accommodated with the exception of the proposed cantilever of the new building adjacent to Grid E	C2	L1	D	enstruct is reviewing in detail the vertical and lateral capacity of the new ED building developing alternate structural schemes)ie steelwork) that will allow proposed building to be accommodated. In addition to this a detailed allowable loading diagram is being sought from the ED building structural consultant				
CS02	Column transfers in new building to ensure columns in new building match HI standard grid of 8.4m x 8.4m	enstruct	Open	enstruct	Design/ Technical	Due to planning requirements of the new ED building several columns were built off the standard HI grid of 8.4m	To provide columns in the new building on the standard HI grid transfer structures will be required which may impact on servicing and/or planning of new building	SICIM consultants have advised that allowance to be made for 1400-1600mm deep concrete transfer beams in areas of column transfer	C3	L1	J	enstruct will develop structural schemes for column transfer of both deep post tensioned floor beams and full floor height steel trusses (which can be located in plant room areas) which will provide options for the column tranfser while minimising impacts on planning and servicing for the new building				
CS03	Proposed lateral structure locations in new building do not match the locations provided for in the new ED building	enstruct	Open	enstruct	Design/ Technical	Due to changes in planning from the documentation phase of the New ED building the preferred location of lateral structure for the new building has modified	Preferred lateral structure locations may apply increased loading to existing ED columns	New ED consultants made some allowance for vertical expansion, however this may not match proposed works. SICIM consultants have undertaken some review of the capacity of building	C3	L2	K	enstruct will develop structural schemes for the preferred building arrangement and for lateral structure elements not aligned with the ED elements below detailed loading capacity review will be undertaken. Through possible strengthening of the new core in the infill area and lightweight floor solutions structural systems will be developed within the limitations of the existing ED building capacity				
CS04	Clash of foundations for new core and link structure with existing services in the courtyard to the north east of the building	enstruct	Open	ct/Services Const	Design/ Technical	The new core/link structure in the infill area will require significant new foundations in an area that has significant inground services	Existing in ground services may require relocation to accommodate required foundation system for the new building works	SICIM consultants have undertaken investigations to identify existing services on site	C2	L2	E	Project consultants will further progress services location within this area and develop either a structural foundation system to avoid existing in ground services or identify services requiring relocation or a combination of both				
CS05	Limited vertical capacity of new ED building upper slabs to accommodate construction loading during concrete placement of lower floors of new building	enstruct	Open	enstruct	Design/ Technical	The upper slabs of the new ED building have been designed for the beams only to support the weight of a new floor during construction	Either self supporting floor systems (ie steel framed) or temporary supporting steelwork will be required during construction of the new floors above the ED	SICIM consultants have identified the loading limitations of the existing floor plates	C3	L1	J	enstruct will work with the project team to determine the best solution for the project, ie either concrete framed with temporary supporting steelwork during construction or a self supporting floor system that does not require back propping				
CS06	Condition of existing structures to be refurbished or connected to in new works and accuracy of the existing documentation that is available	enstruct	Open	enstruct	Design/ Technical	Condition of existing structure to be impacted by the new works and accuracy of the existing documentation will be required	If the actual condition of existing structure or accuracy of the structural documentation relied upon for design of these elements is not correct these works may be incorrectly detailed and scoped with potential cost impacts	SICIM consultants have undertaken high level investigation of existing structures likely to be impacted by new works	C2	L3	H	enstruct will continue the works commenced by the SICIM consultants and scope/undertaken further investigations necessary to ensure that the existing structure is understood in detail				
CS07	Design and construction of structural system will need to accommodate operating helipad immediately to the south east of the new building for the full duration of construction	enstruct	Open	enstruct	Design/ Technical	The existing helipad will be required to remain operation during construction and is immediately adjacent to the construction site	Helicopter operations will generate significant down draft across the construction site and helipad will need to remain compliant with operator requirements	Nil	C2	L1	D	enstruct will look to develop structural systems that can be constructed without impact from the helicopter operations and that do not impact on the helipad operation. Detailed consideration and ultimate ownership of this will be required by the contractor.				

Consequence rating: C1=catastrophic, C2=major, C3=moderate, C4=minor, C5=minimal
Likelihood rating: L1=almost certain, L2=likely, L3=possible, L4=unlikely, L5=rare

Identification				Category		Analysis			Risk Rating 1			Treatment		Risk Rating 2		
Risk ID	Risk Name	ID'd by	Status	Risk Owner	Category	Cause(s)	Effect / Consequence	Existing Controls	C	L	Risk Rating	List further tasks required to reduce risk to acceptable level	Due date	C	L	Risk Rating
	Risk Item Subject	Company Initials	Open or Closed	Company Initials	Risk Category	Short Description	Short Description	Short Description	Consequence Rating - Refer Matrix Tab e.g. C5	Likelihood Rating - Refer Matrix Tab e.g.. L3	Overall Rating - Refer Matrix Tab - e.g.. A, B, C...etc.	Short Description	Date	Consequence Rating - Refer Matrix Tab e.g. C5	Likelihood Rating - Refer Matrix Tab e.g.. L3	Overall Rating - Refer Matrix Tab e.g.. A, B, C...
CIVIL & STRUCTURAL																
CS08	Variability in geotechnical conditions for new foundations works required for building outside of the new ED building footprint	enstruct	Open	enstruct	Design/ Technical	Potential variability in ground consditions existing with all in ground works	Unexpected in ground conditions can cause modifications to foundation systems during construction which can have both cost and program implications	SICM consultants have undertaken some geotechnical investigations which are ongoing	C3	L3	M	enstruct will continue to work with the project geotechnical consultant to ensure that sufficient investigation and utilisation of existing site data (previous investigations and logs of new ED foundations) are undertaken to minimise this risk				
CS09	Construction of the building will be undertaken immediately over an operating ED	enstruct	Open	enstruct	Design/ Technical	The construction works for the new building will be undertaken immediately above a functioning ED within a constrained hospital site	Conventional construction techniques would likely generate impacts (noise and vibration) on the operating ED that would be unacceptable	Nil	C2	L1	D	enstruct will develop structural systems that can be constructed with conventional construction techniques that do not generate unacceptable levels of noise and vibration. Access to site and materials handling will also require detailed consideration. Detailed consideration and ultimate ownership of this will be required by the contractor.				
CS10	Location of movement joint in new ED building below	enstruct	Open	enstruct	Design/ Technical	The new ED building has a permanent movement joint in the structure running across the short direction of the building	If the movement joint is retained 2 sets of lateral structure will need to be provided and the location of this joint will need to be respected by all planning of new works	Nil	C3	L1	J	enstruct will investigate if the permanent movement joint can be replaced with a temporary movement joint in the new construction which would eliminate this risk. If not possible detailed planning will be undertaken with all project consultants to minimise the impact of this joint.				

APPENDIX A

HI Structural Design Guidance Note

STRUCTURAL DESIGN CRITERIA GUIDELINES

The purpose of this Design Guidance Note is to record and communicate the main guidelines developed from a Health Infrastructure (HI) structural design criteria workshop.

The intended audience for this Design Guidance Note is HI engaged structural engineering consultants with a view to standardising the structural design criteria across HI projects.

This Design Guidance Note is intended as a guideline only and it is considered that project specific circumstances will require these principles to be reviewed by each project team to confirm appropriateness.

BACKGROUND

On Tuesday 18 April 2012, HI convened a structural design criteria workshop with the view of standardising structural design criteria arising from the 'Systemised Design Brief'. The workshop was facilitated in response to both queries from HI structural engineering consultants regarding design criteria and also due to awareness by HI that different project teams were adopting different design criteria in the similar circumstances, in particular with regard to vibration and provisioning for future use.

The workshop was attended by selected Structural Engineering Consultants engaged on current HI projects, the representatives of the HI ERG and a HI PD representative.

STRUCTURAL DESIGN CRITERIA GUIDELINES

The workshop outcomes resulted in the recommendation of the following guidelines for structural design criteria:

1. **Preference for a standard 8.4 x 8.4m design grid.**

2. **Sacrificial Cover for future provisioning of wet areas.**

   Preference is for an additional 40mm integral, unreinforced sacrificial cover above the minimum 20mm cover.

   It was viewed that if design was not progressed sufficiently at time of construction to allow set out of wet areas, then preference was to install oversized set-downs in approximate wet areas locations in lieu of installing a future topping screed. Reasoning for this;

   - 40-50mm topping screed – concerns with bonding / drummyness. 75mm considered minimum.
   - Topping screed to whole slab will be on fit out critical path rather than local cutting out that can occur concurrently with fit out.

   It was agreed that a sample should be carried out to assess the noise impacts of the removal of the topping – this would best occur on a current project.

3. **Design criterion.**

   - Deflection limitation to be in accordance with relevant Australian Standards, ie AS 3600, and total long term deflection of Span/250 or 25mm whichever is more onerous.
   - Design to consider two design criterion to ensure that ultimate strength, minimum strength and crack control requirements are met for all initial and future arrangements. The two design criterion to be considered are:
     - Structural Design Criteria 1 – Vibration Design - Integral 40mm sacrificial zone considered as structural in analysis.

     - Structural Design Criteria 2 – Limit State and Serviceability design (Strength & deflection) - 40mm sacrificial zone considered as non-structural, i.e. as a superimposed dead load.

   Refer to **Attachment A** – Structural Design Criteria for details.

   - Loading – Specific loading areas to be assessed on a case-by-case basis to meet the relevant standards. As a guideline for future flexibility:
     - Superimposed Dead Load (SDL) – To make allowance for partitions, ceilings, services etc and any non-structural screed zones. Refer to Attachment A for details. Live Load (LL) - Generally 3kPa (minimum) unless there are specific loading code requirements.
   - Structural Vibration
     - Self-weight – Full self-weight applied in vibration analysis.
     - Vibration excitation sources to be considered are continuous or intermittent sources of vibration such as footfall or vibration from non-isolated plant.
     - Response Factor (RF):
       - At the commencement of structural design, the proposed structural design criteria is to be submitted to HI for review in the format of Attachment B.
       - RF of 1.0 to areas (including immediate floor above) for theatres, imaging and other sensitive areas. Consideration should be also given to podium levels or other that may be considered to require a higher degree of future flexibility.
       - RF of 2.0 generally for clinical and common areas.
       - Plant areas, basements and other back of house areas not likely to be subject to future flexibility to comply with ISO 10137 2007 (Basis for design of structures).
       - Steel serviceability posts should not be introduced to meet RF design criteria without express approval as can limit future use.

4. **Typical penetration arrangement adjacent to columns and zone for future penetrations.**

   Various arrangements were reviewed and concerns with punching shear when penetrations located on two sides of columns. The following typical arrangement is preferred (on one side of column only for internal columns). It is noted that this preference will also be a determining factor in the specification of band width and separation in a post tensioned banded slab design.

   Refer **Attachment C** - Sketch Typical Peno.

5. **Two way slabs (drop panels) Vs 1 way slabs (banded).**

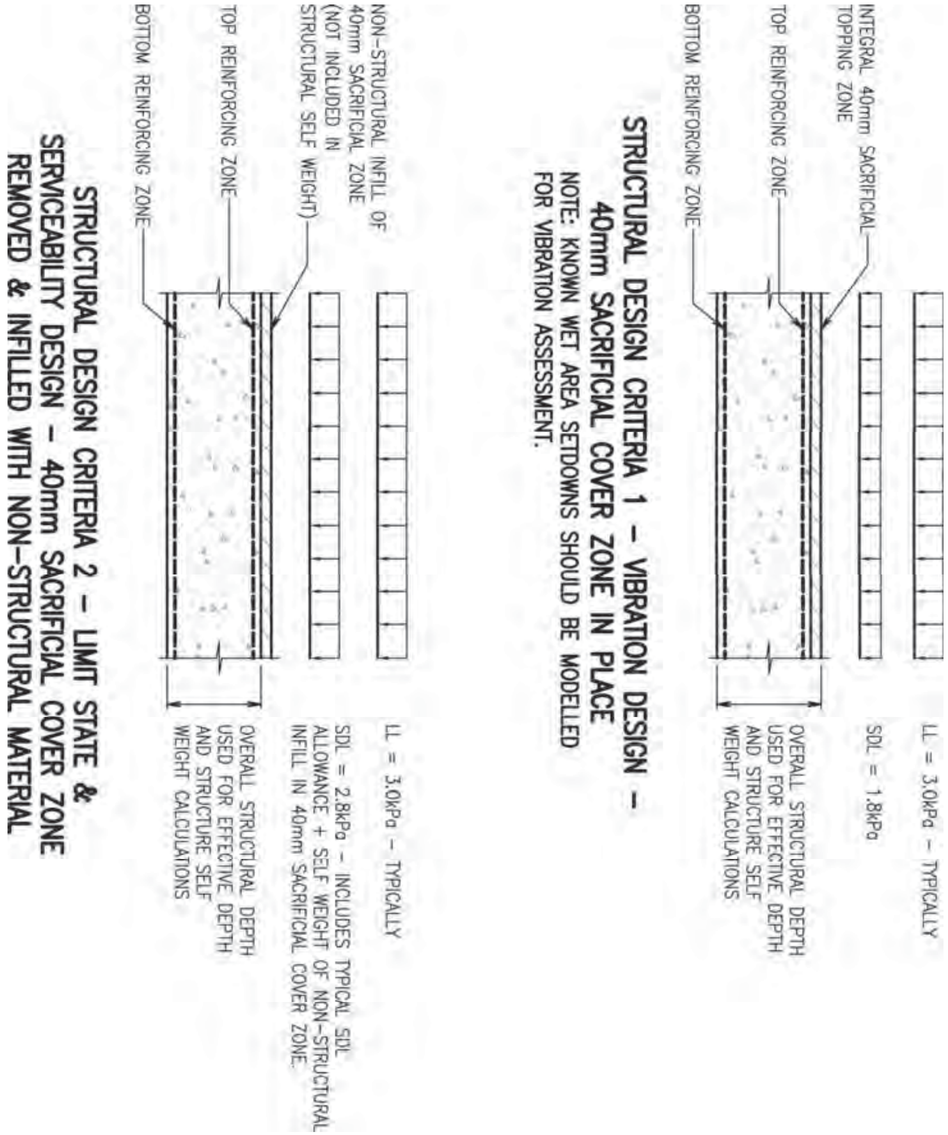
   - To be determined on a project by project basis considering floor to floor heights and services coordination constraints
   - Floor to floor heights of less than 4.2m likely to require drop panels and acknowledged that with 4.2m floor to floor min that banded slabs generally provide sufficient ceiling zone for services coordination.
   - Acknowledged that market preference from a formwork perspective is for banded slabs due to programme and cost benefit.
   - Designs for banded slabs to always allow for option of conventional formwork if design based on proprietary systems ie Ultra Shell band beams or Bondek/KingFlor to slab soffits etc.
   - To accommodate typical penetration arrangement above, band beams should not be documented less that 2200 wide. (This would not necessarily apply where the band beam runs parallel to the 600 dimension of the penetration. In this case Band beam design to be of

sufficient width to accommodate the future penetration requirements). This will need to be assessed on a case by case basis.

ATTACHMENTS

Attachment A - Structural Design Criteria
Attachment B - Structural Design Criteria
Attachment C - Sketch Typical Peno

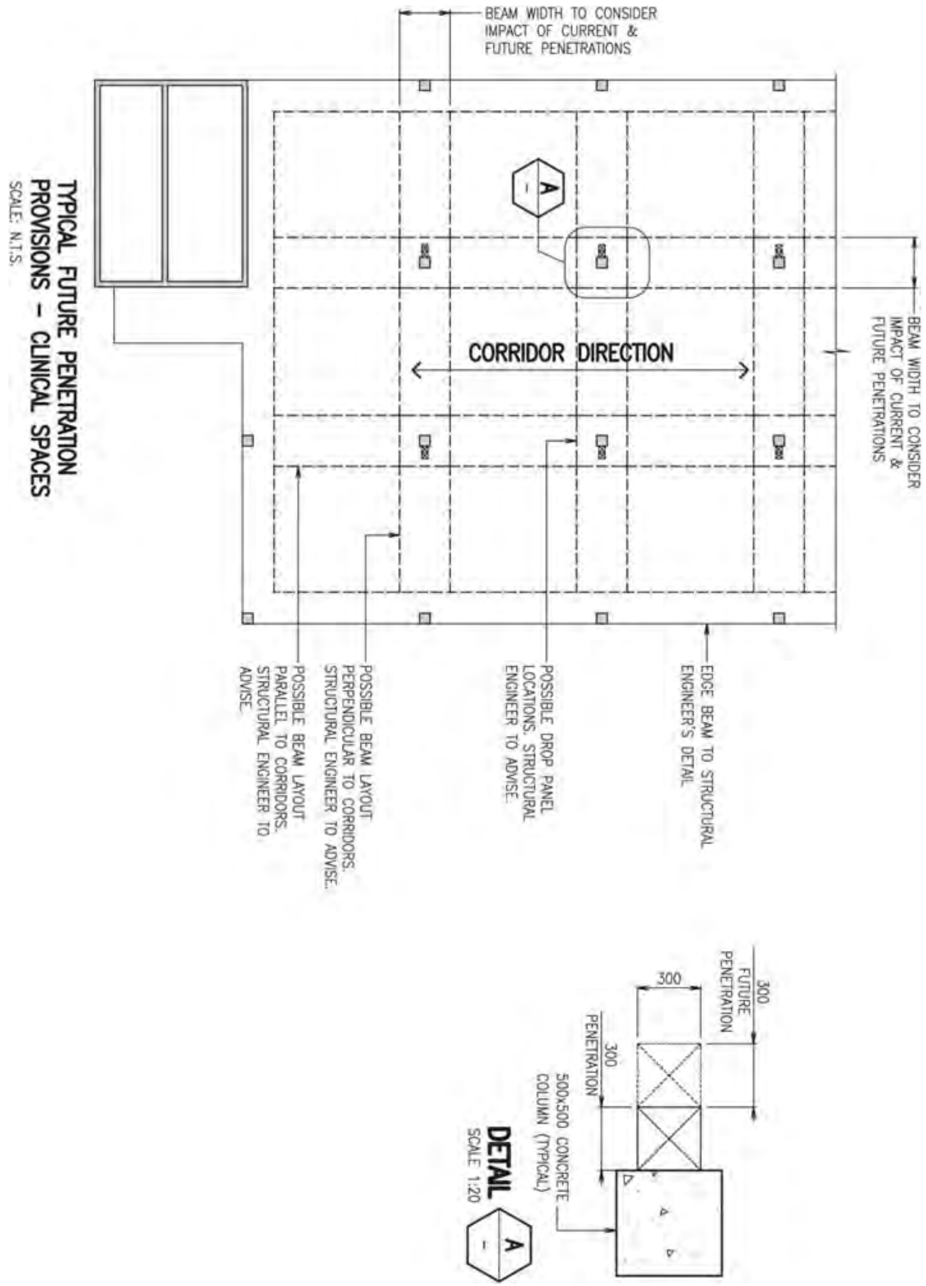
Attachment A - Structural Design Criteria



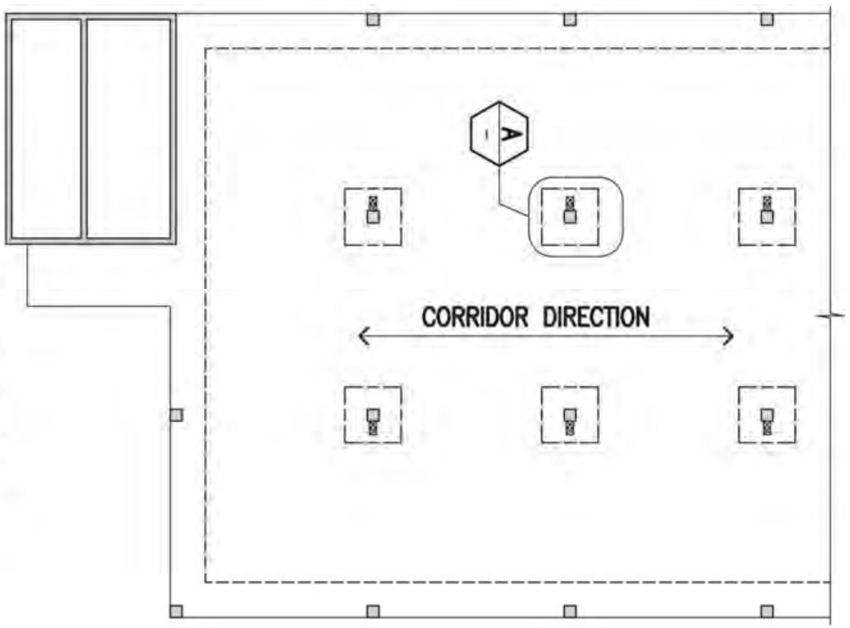
Attachment B - Structural Design Criteria

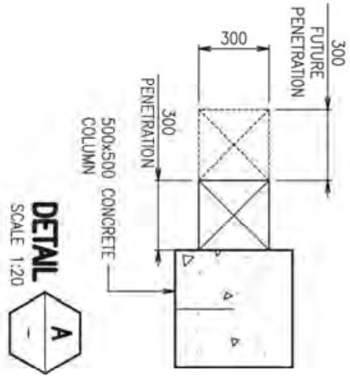
Criteria	Guide	Adopted
Damping	3.0-3.5%	
Walking Pace Frequency (rooms / corridors)	2.1-2.5Hz	
Walking Pace Frequency (Theatres / imaging)	2.1-2.5Hz	
Sacrificial topping included	Yes	
Adopted RF to project *- Theatres / imaging* *- IPU levels* *- Emergency* *- Podium Levels* *- Other*		

Attachment C - Sketch Typical Peno



TYPICAL FUTURE PENETRATION PROVISIONS – CLINICAL SPACES
SCALE: N.T.S.





DETAIL
SCALE 1:20

APPENDIX B

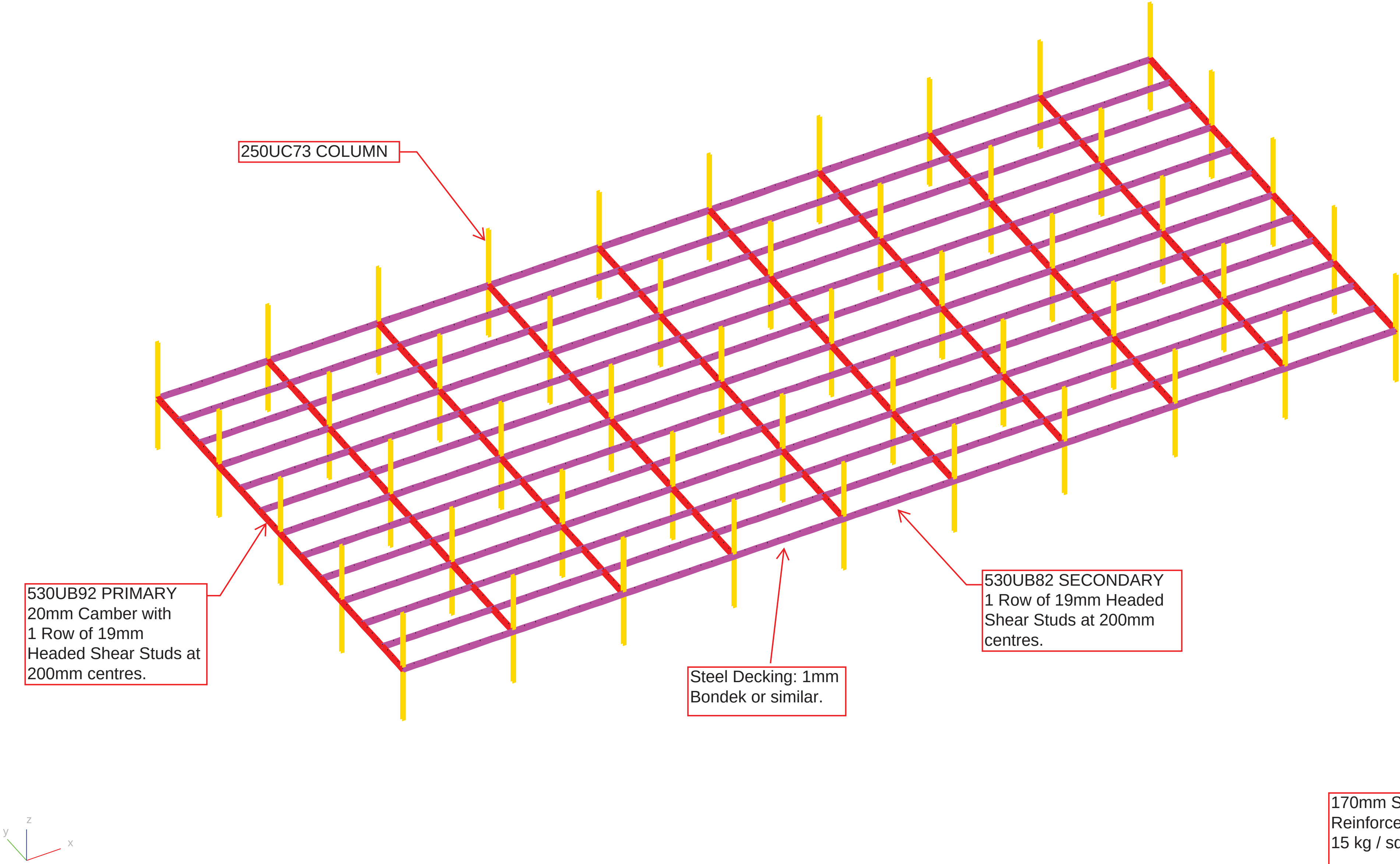
Suspended Floor Plate Options

enstruct

St. George Hospital Redevelopment

Job No.	Sheet No.	Rev.
4815	1/1	B
Drg. Ref. SK-001		
Made by JDD	Date 11-Aug-14	Checked

Element list: "Steel"
Scale: 1:261.8
Highlighted:
Coincident Nodes
Coincident Elements

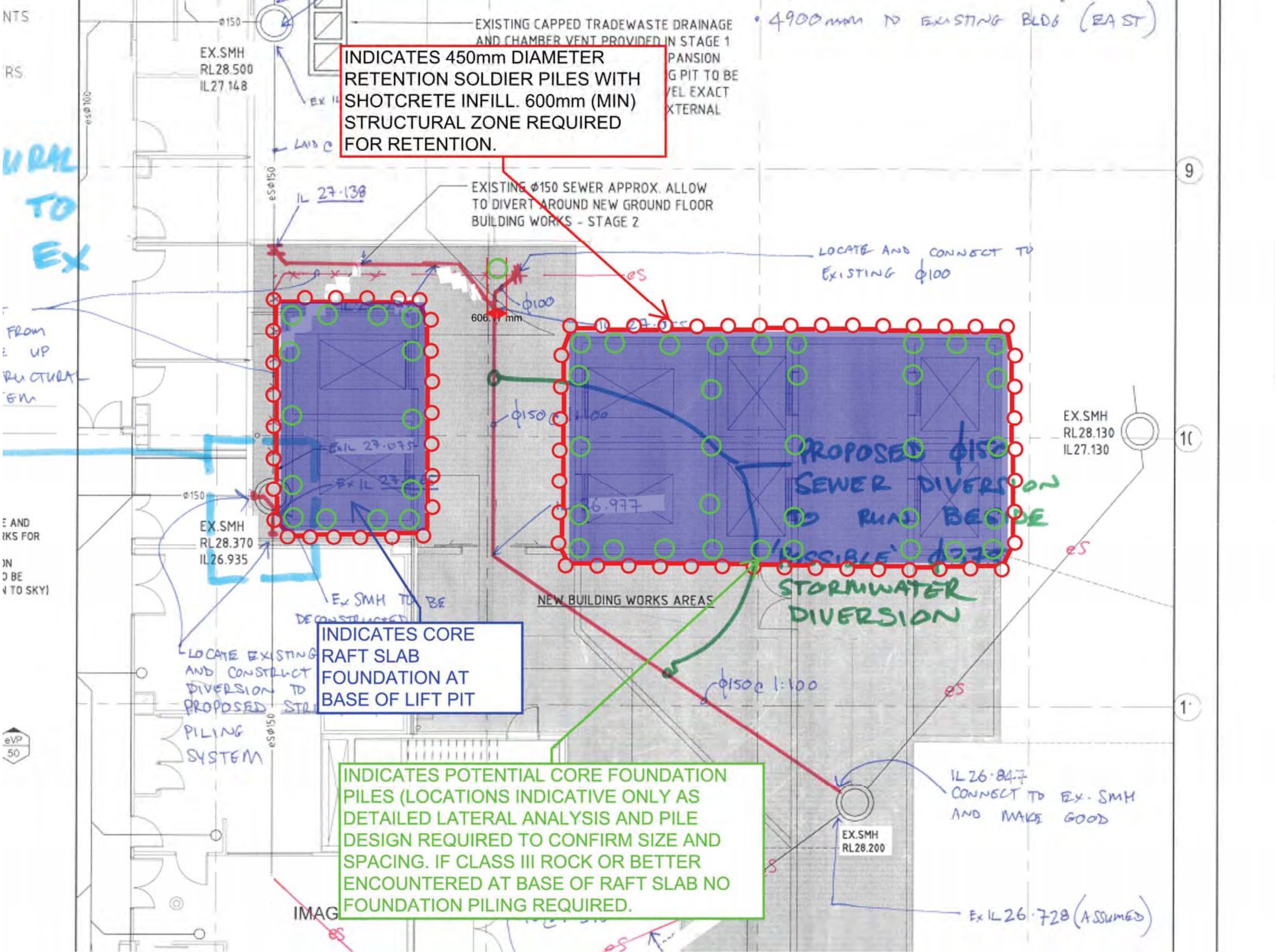


170mm Slab
Reinforcement Rate:
15 kg / sqm

enstruct

APPENDIX C

Main Core Retention and Foundation Structural Concept

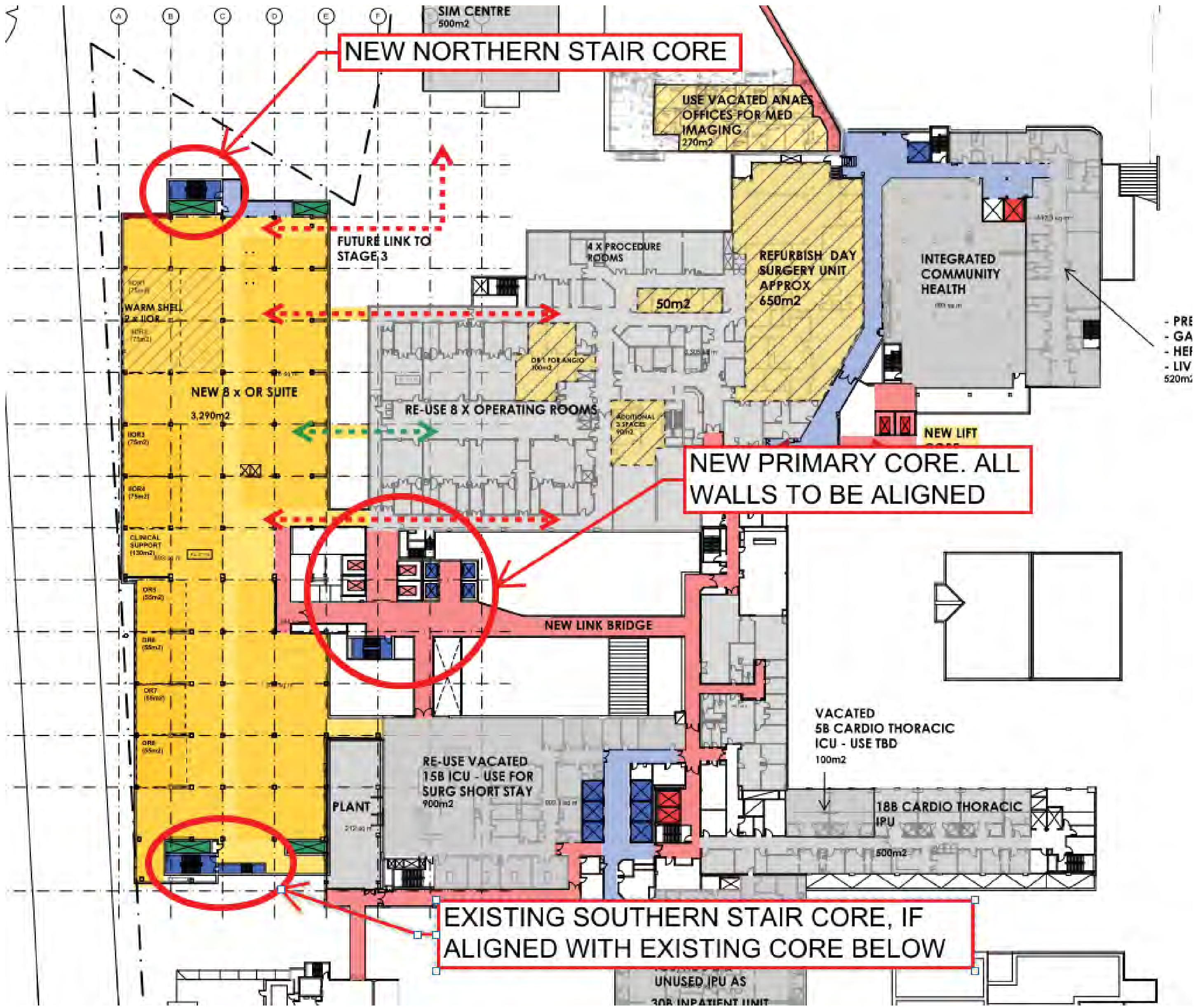


EXISTING CAPPED TRADEWASTE DRAINAGE AND CHAMBER VENT PROVIDED IN STAGE 1
INDICATES 450mm DIAMETER RETENTION SOLDIER PILES WITH SHOTCRETE INFILL. 600mm (MIN) STRUCTURAL ZONE REQUIRED FOR RETENTION.
4900mm TO EXISTING BLDG (EAST)
EX.SMH
RL28.500
IL27.148
EXISTING ø150 SEWER APPROX. ALLOW TO DIVERT AROUND NEW GROUND FLOOR BUILDING WORKS - STAGE 2
IL 27.138
LOCATE AND CONNECT TO EXISTING ø100
ø100
606.17 mm
ø150 @ 1:100
EX.SMH
RL28.130
IL27.130
PROPOSED ø150 SEWER DIVERSION TO RUN BESIDE
STORMWATER DIVERSION
EX.SMH
RL28.370
IL26.935
Ex SMH TO BE DECONSTRUCTED
NEW BUILDING WORKS AREAS
INDICATES CORE RAFT SLAB FOUNDATION AT BASE OF LIFT PIT
LOCATE EXISTING AND CONSTRUCT DIVERSION TO PROPOSED STRUCTURAL PILING SYSTEM
ø150 @ 1:100
INDICATES POTENTIAL CORE FOUNDATION PILES (LOCATIONS INDICATIVE ONLY AS DETAILED LATERAL ANALYSIS AND PILE DESIGN REQUIRED TO CONFIRM SIZE AND SPACING. IF CLASS III ROCK OR BETTER ENCOUNTERED AT BASE OF RAFT SLAB NO FOUNDATION PILING REQUIRED.
IL 26.847
CONNECT TO EX. SMH AND MAKE GOOD
EX.SMH
RL28.200
Ex IL 26.728 (ASSUMED)
9
10
11

APPENDIX D

Indicative Building Lateral Requirements

enstruct



NEW NORTHERN STAIR CORE
SIM CENTRE 500m2
USE VACATED ANAES OFFICES FOR MED IMAGING 270m2
FUTURE LINK TO STAGE 3
4 X PROCEDURE ROOMS
50m2
REFURBISH DAY SURGERY UNIT APPROX 650m2
INTEGRATED COMMUNITY HEALTH
WARM SHELL 2 x IIOR
NEW 8 x OR SUITE 3,290m2
RE-USE 8 X OPERATING ROOMS
NEW LIFT
NEW PRIMARY CORE. ALL WALLS TO BE ALIGNED
CLINICAL SUPPORT
NEW LINK BRIDGE
VACATED 5B CARDIO THORACIC ICU - USE TBD 100m2
RE-USE VACATED 15B ICU - USE FOR SURG SHORT STAY 900m2
PLANT
18B CARDIO THORACIC IPU
500m2
EXISTING SOUTHERN STAIR CORE, IF ALIGNED WITH EXISTING CORE BELOW
UNUSED IPU AS

FOR GENERAL NOTES REFER TO DRAWING SGHED-S-100

LEVEL 1 - NORTH

SCALE: 1 : 100

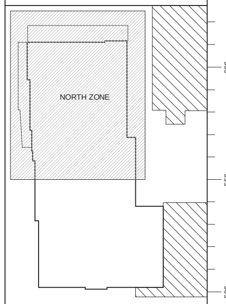
COLUMN SCHEDULE			
MARK	DESCRIPTION	SIZE (W x D)	F'c (MPa)
C1	ED COLUMN	600 x 600	50
C2	ED COLUMN	400 x 600	50
C3	ED COLUMN	700 DIA.	50

CONCRETE BEAM MEMBER SCHEDULE	
MARK	SIZE (W x D)
B1	2400w x 420d
B2	450w x 420d
B3	1200w x 420d
B8	900w x 420d
B10	600w x 720d
B11	1850w x 420d
B12	1600w x 420d
B13	1500w x 520d

NOTES:

ALL STAIR WALLS TO BE 190 THICK REINFORCED CONCRETE U.N.O.
ALL LIFT WALLS TO BE 190 THICK REINFORCED CONCRETE U.N.O.
ALL RC WALLS TO BE 190 THICK U.N.O.
150 WIDE UPTURN HEIGHTS TO ARCHITECTS SPECIFICATION
75 MINIMUM TOPPING SLAB WHERE ARCHITECT SHOWS OVER LEVEL 1 SLABS. SL82 MESH. FALLS TO ARCH. SAWN JOINTS AT MAX 5m CTS.
SETDOWN LOCATIONS IN TOPPING SLAB REFER TO ARCHITECTS DRAWINGS

DENOTES AREA OF BEAM ZONED REINFORCEMENT FREE



REV	REVISION DESCRIPTION	DATE	BY
C 3	CONSTRUCTION ISSUE	05/09	PP
C 2	REINFORCEMENT FREE ZONES AMENDED	17-05	PP
C 1	CONSTRUCTION ISSUE	29-11	PP

QA CHECK

Subject	By	Date	Subject	By	Date
RDS			STRUCT		
ARCH			SPEC. CONS		
AUT			SERV		

Project
ST GEORGE HOSPITAL
EMERGENCY DEPARTMENT

Principal
NSW Health Infrastructure

TRUE NORTH

PROJECT NORTH

HEALTH PROJECTS INATERNATIONAL
Architects and Health Facility Planners
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Ground Floor, Suite 1, 68 Alfred Street
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USE FIGURED DIMENSIONS ONLY. DO NOT SCALE. ALL DIMENSIONS SHALL BE VERIFIED ON SITE AND DISCREPANCIES IMMEDIATELY BROUGHT TO THE ATTENTION OF THE PROJECT MANAGER FOR RESOLUTION.

"CLOUDS" & REVISIONS ARE INTENDED AS GUIDES AND NOT NECESSARILY DESCRIBE THE FULL EXTENT OF REVISIONS.
ASCERTAIN FULL EXTENT BY COMPARISON WITH PREVIOUS VERSION

CIVIL, STRUCTURAL AND TRAFFIC: Cardno
MECHANICAL, ELECTRICAL AND MEDICAL GAS: Umow Lai
HYDRAULIC AND FIRE: AcOR
PROJECT MANAGER: sweett

Block/ Zone: NORTH ZONE
Drawn: C.R.S
Checked: T.K
Date: SEPT 2012
Scale (B1 SIZE): 1 : 100
Drawing Title: LEVEL 1 PLAN - NORTH ZONE
CAD File: REVIT 2012
Dwg. No.: SGHED-S- 120
Issue: C3

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FOR GENERAL NOTES REFER TO DRAWING SGHED-S-100

LEVEL 1 - SOUTH

SCALE: 1 : 100

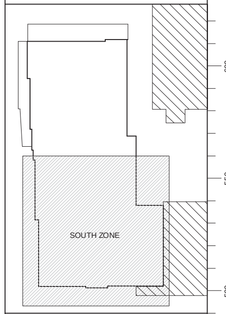
CONCRETE BEAM MEMBER SCHEDULE	
MARK	SIZE (W x D)
B1	2400w x 420d
B2	450w x 420d
B3	1200w x 420d
B8	900w x 420d
B10	600w x 720d
B11	1850w x 420d
B12	1600w x 420d
B13	1500w x 520d

COLUMN SCHEDULE			
MARK	DESCRIPTION	SIZE (W x D)	F'c (MPa)
C1	ED COLUMN	600 x 600	50
C2	ED COLUMN	400 x 600	50
C3	ED COLUMN	700 DIA.	50

NOTES:

STAIR WALLS TO BE 190 THICK REINFORCED CONCRETE U.N.O.
LIFT WALLS TO BE 190 THICK REINFORCED CONCRETE U.N.O.
ALL RC WALLS TO BE 190 THICK U.N.O.
75 MINIMUM TOPPING SLAB WHERE ARCHITECT SHOWS OVER LEVEL 1 SLABS. SL82 MESH. FALLS TO ARCH. SAWN JOINTS AT MAX 5m CTS.
SETDOWN LOCATIONS IN TOPPING SLAB REFER TO ARCHITECTS DRAWINGS.

DENOTES AREA OF BEAM ZONED REINFORCEMENT FREE



REV	REVISION DESCRIPTION	DATE	BY
C 6	REINF. FREE ZONES ADDED	09/09	PP
C 5	CONSTRUCTION ISSUE	05/09	PP
C 4	CO-ORDINATION ISSUE	27/08	PP
C 3	FOR INFORMATION	16/08	PP
C 2	REINFORCEMENT FREE ZONES AMENDED	17-05	PP
C 1	CONSTRUCTION ISSUE	29-11	PP

QA CHECK

Subject	By	Date	Subject	By	Date
RDS			STRUCT		
ARCH			SPEC. CONS		
AUT			SERV		

Project
ST GEORGE HOSPITAL
EMERGENCY DEPARTMENT

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ASCERTAIN FULL EXTENT BY COMPARISON WITH PREVIOUS VERSION

CIVIL, STRUCTURAL AND TRAFFIC: Cardno Shaping the Future

MECHANICAL, ELECTRICAL AND MEDICAL GAS: Umow Lai

HYDRAULIC AND FIRE: AcOR

PROJECT MANAGER: sweett

Block/ Zone	Drawn	Checked	Date	Scale (B1 SIZE)
SOUTH ZONE	C.R.S	T.K	SEPT 2012	1 : 100

Drawing Title: LEVEL 1 PLAN - SOUTH ZONE

CAD File	Dwg. No.	Issue
REVIT 2012	SGHED-S- 121	C6

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APPENDIX E

Qualitative Comparison of Concrete and Steel Framed Floor Plate Options

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St George Hospital Redevelopment

Qualitative Assessment/Comparison of Steel and Concrete Framed Floor Plate Systems

The following presents a comparison of qualitative items for both steel and concrete framed floor plate for the St George Hospital Redevelopment project.

Lateral System

For both the steel and concrete framed floor plates the lateral system proposed for the project consists of cast in-situ reinforced concrete core elements being the primary core on the eastern side of the building which contains the lifts and the northern and southern stair shafts at the ends of the building.

For both floor plate options a critical item of the program will be commencement and progression of the main lift core structure as detailed in ground works need to be completed prior to commencement of the core wall construction. For both floor plate options the main lift core structure needs to progress with the construction of the overall building structure to maintain lateral stability with a maximum lag between the active floor plate and the main lift core structure of 1-2 floors for both.

Crane Strategy

Due to the size of the building (approximately 108m x 33m for the main floor plate plus the main lift core structure to the east) and the constrained nature of the site detailed consideration of the crane location will be required by the contractor and a larger capacity crane is likely to be required to provide hook access to all areas of the floor plate. It is likely that to limit the project to a single tower crane a crane location close to the centreline of the building in the east west direction will be required.

The required lifting capacity of the crane for both the steel and concrete framed floor plates will be of similar magnitude.

The steel framed floor plate will require increased overall crane time than the concrete framed option due to number of pieces that need to be lifted into place. For this project given the limited available locations for tower cranes and the reaches required due to the size of the floor plate it is expected that a steel framed floor plate would implement an erection strategy that would limit the tower crane use to lifting bundles of steel onto the floor plate with erection of the steelwork undertaken by mini crawler type cranes located on the completed floor plate below to limit tower crane lifts to large bundles of steelwork off delivery vehicle and allow erection to occur simultaneously on several fronts. If this strategy is implemented the tower crane demand for steel and concrete framed floors is likely to be similar, however if all steelwork is erected by the tower crane the tower crane usage will be far higher for the steel framed floor plate option.

Scaffolding/Hoarding Strategy

Both the hoarding and scaffolding strategy for the steel and concrete are likely to be similar, with the preferred systems for these driven by elements other than the floor plate construction.

In regards to hoarding it is likely that significant hoarding will be provided along Gray St to provide protection to the public. Due to the constrained nature of the site the contractor will also need to identify a location for both site amenities (ie site sheds etc) and also a loading/staging area for handling of construction materials, it is likely that the areas for these uses will be located on a raised hoarding platform. For both the steel and concrete framed building the requirements for loading/staging areas is likely to be similar with the majority of materials able to be craned directly onto the deck with a possible reduction in site amenities for the steel framed option due to the reduced workforce required on site.

Edge protection and access to the perimeter of the building is likely to be driven by the selected façade system. With floor by floor type façade system it is expected that scaffolding will be provided to provide the required access to the external perimeter of the building which would be required during the installation of this type of façade system. For a curtain wall type façade system it is expected that perimeter screens would be provided to provide the necessary access to allow the curtain wall to be installed. With neither floor plate option being more or less suited to either of these systems. A steel framed floor does offer one advantage to a concrete framed floor for edge protection in that if handrails are required the handrails and edge protection can be connected to the perimeter steel beams prior to erection resulting in a completed handrail/edge protection system as soon as the perimeter beam is erected.

Façade Strategy

In regards to suitability of façade systems both the steel and concrete framed floor plates can readily accommodate either a curtain wall or floor by floor façade type system. Connections of façade systems to the floor plate in a steel framed floor plate is made via connections provided during the fabrication of the steelwork avoiding site work for the installation of these whereas a concrete framed floor plate would typically have recesses and cast-in elements constructed on site as the floor plate is prepared for concrete placement.

Installation of façade is likely to be able to commence earlier with a steel framed floor plate offering some program benefits. As the steel framed floor plate does not require backpropping access for façade installation can commence immediately after concrete placement of the floor above, whereas for a concrete framed floor plate with backpropping estimated to be required on 3 floors below the deck being constructed access for façade installation will trail the active deck by 3 floors.

Workforce

A steel framed floor plate allows for a significantly reduced workforce on site during construction of the building structure:

- With all steelwork prefabricated off-site the onsite workforce requirements for the structural steel framing is limited to the erection crew;
- As the formwork for a steel framed building is provided via composite metal decking which is scheduled and fabricated offsite, does not require backpropping

or secondary support structure the formworking crew and the time they spend onsite is significantly reduced;

- Reinforcing for a steel framed building typically consists of a constant mesh across the floor plate with a recued tonnage and complexity when compared to scheduled and fabricated bar and PT required for a concrete floor plate, resulting in reduced time and workforce being required for slab reinforcing/PT installation;
- Post tensioning is removed from the floor plate which not only removes the need for installation of the PT but also the removal of the requirement for stressing at 1 and 4 days after concrete placement;
- With a reduced concrete volume associated with a steel framed floor plate the concrete placement workforce requirements are significantly reduced compared to a concrete framed floor plate (see materials handling section for further details);
- An additional structural trade is required for the application of the fire spray to the structural steelwork with the size of this workforce expected to be limited to a small number of workers.

Materials Handling

For structural steelwork with the steelwork, composite metal decking and slab reinforcing being delivered to site bundled ready for craning directly to the active deck in large bundles, which is expected to place reduced materials handling demands compared to that required for a concrete framed floor plate when compared to the materials handling requirements for the formwork, slab reinforcing and post tensioning. Steelwork has an increased demand for localised materials handling on the active deck which as outlined in the carnage strategy section is expected to be accommodated with on floor mini crawler type cranes.

A significant point of difference between a steel and concrete framed floor plate in regards to materials handling is the required concrete volume. For a typical steel framed floor plate every 1000m^2 of floor plat requires 170m^3 of concrete (approximately 28 concrete trucks based on a 6m^3 truck capacity) whereas 1000m^2 of typical concrete framed floor plate requires 280m^3 of concrete (approximately 47 concrete trucks based on a 6m^3 truck capacity), which is a 40% reduction in concrete that needs to be placed which significantly reduces both the number of concrete trucks required to site and also the workforce needed for the concrete placement.

Helipad Strategy

During construction of either a steel or concrete framed floor plate the impact of the existing helipad operating adjacent to the construction site is likely to be similar for both arrangements. With scaffolding and edge protection needing to be designed for increased wind pressures associated helicopter downdraft, loose materials needing to be avoided on site and carnage needing to cease during helicopter arrival and departure.

Similarly both the steel and concrete framed floor plate options are both able to accommodate the requirements of the future helipad on the new AST.

Fire Rating

Due to the inherit fire rating of concrete structure no additional works are required to achieve the necessary fire ratings for the building.

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A steel framed floor plate will require the application of a fire rating material to achieve the necessary fire rating levels which needs to be undertaken after erection of the steelwork and the composite metal decking is complete. As a 120/120/120 FRL is required for the structure it is expected that the most efficient fire rating solution for the steelwork would be the application of a fire spray material to the steel beams (ie vermiculite type material) with the application of this typically occurring immediately below the active deck. With a fire engineering approach it is expected that the steelwork requiring fire protection would be limited to the primary beams and secondary beams on grid, with the exception of areas with fire walls where all secondary beams are likely to require fire protection.

Movement Joints

With the steel framed floor plate having a reinforced concrete slab with a continuous layer of reinforcing it is expected that the movement joint (both temporary and permanent) will be removed. As the continuous layer of reinforcing ensures that cracking due to shrinkage and restraint is evenly distributed across the floor plate in minor cracks of an acceptable width no movement joint is expected to be required.

For a concrete framed floor plate as the reinforcing across the floor plate is not continuous due to the slab being a post tensioned slab a temporary movement joint will be required through the middle of the floor plate to allow a significant proportion of the movement of the floor plate due to shrinkage, creep etc to occur prior to locking the floor plate together to ensure that cracking of the floor plate is controlled. This temporary movement joint will need to be left in place for 3 months after concrete placement.

Safety

Through a combination of factors such as:

- Structural steel fabrication is undertaken in factory controlled environments, off site, where the safety risks are lower and finish quality be more readily controlled;
- Reduction in manual materials handling;
- Access to heights undertaken via mobile work platforms;
- Steel framing being self-supporting once erected;
- Ability to pre-connect handrails and other safety systems prior to erection.

It is generally recognised in the industry that a floor plate framed from steel offers an opportunity to increase site safety when compared to a concrete framed floor plate.

Backpropping and Access for Following Trades

A steel framed floor plate system is self-supporting which does not require backpropping. The removal of backpropping allows following trades such as façade and services installation to follow immediately below the active deck. The self-supporting arrangement of a steel framed floor plate does not require any support from the existing ED Building Level 1 slab.

A concrete framed floor plate system is estimated to require backpropping to extend 3 levels below the active deck to mobilise sufficient slab capacity to carry the weight of a wet concrete deck during concrete placement through to final stressing of the post tensioning. This back propping limits the access for following trades such as façade and services installation until the backpropping has been removed requiring these works to be undertaken 4 floors below the active deck. Based on advice from the SICIM structural consultant (Cardno) the ED Building Level 1 slab is understood to have the following capacities in regards to supporting the weight of the floor above during concrete placement:

- Beams – Provided with sufficient capacity to support the weight of the slab above during construction so no propping or strengthening of these beams is required during construction of the floors above;
- Slabs – Have insufficient capacity to support the weight of the slab above during construction and will require a grillage of steelwork to transfer the loading in the slab areas back to the supporting beams during construction of the floor above (backpropping of the slab is not feasible due to the operating ED facility below).

Structural Weight

The weight of a steel framed floor plate is approximately 40% less than that of a concrete framed floor plate. This allows additional floor area to be constructed with steel framed floor plates without strengthening of the existing structure below in areas where planning requires an increase in floor area from that allowed for during the design and construction of the ED Building.

Wastage

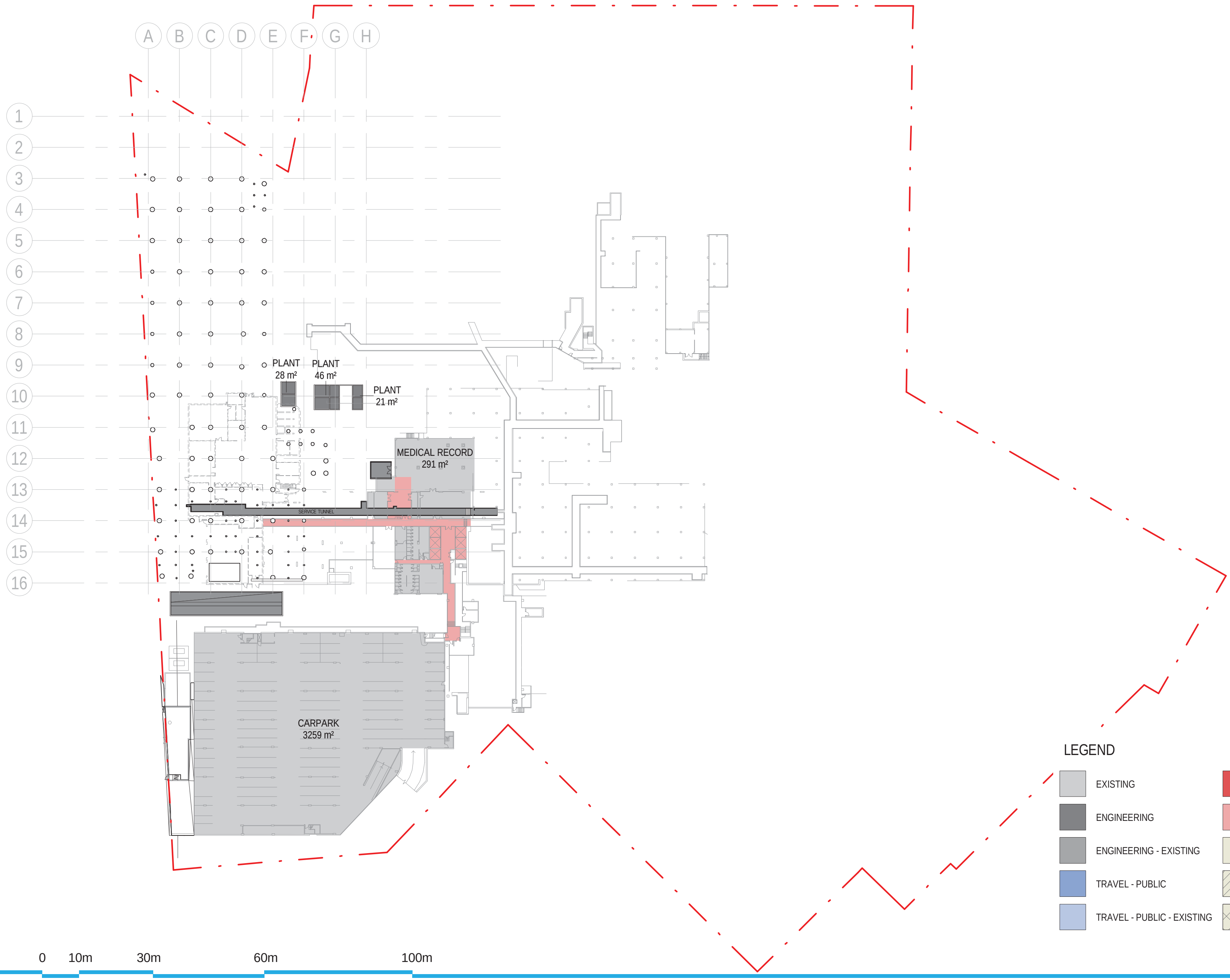
Almost all materials delivered to make a composite structural steel frame will stay on site with structural steel is fabricated to suit its final location, composite decking scheduled & cut off-site to suit precise areas, eliminating on-site cutting of decking and minimising wastage, reinforcement is scheduled for specific locations, also minimising wastage. Whereas for concrete framed floor plates fabrication effectively occurs on site with site wastage typically increased compared to steel framed construction.

Impact to ED Below

For the steel framed floor plate the construction activities on the roof of the ED (Level 1 floor plate) are limited to construction access for construction personal and movement of mobile working platforms. For the concrete framed floor plate the activities to the roof of the ED include the above items for the steel framed floor plate in conjunction with installation of backpropping/formwork and temporary steelwork grillage. Given the required construction of additional items on the Level 1 floor plate it is expected that there is a higher risk of noise or vibration impact being generated by the construction of the concrete framed floor plate.

APPENDIX F

North East Corner Option 1 Planning Arrangement
Structural Transfer Systems



LEGEND

EXISTING	TRAVEL - STAFF
ENGINEERING	TRAVEL - STAFF - EXISTING
ENGINEERING - EXISTING	NEW BUILD
TRAVEL - PUBLIC	REFURBISHMENT
TRAVEL - PUBLIC - EXISTING	POTENTIAL EXPANSION

0 10m 30m 60m 100m

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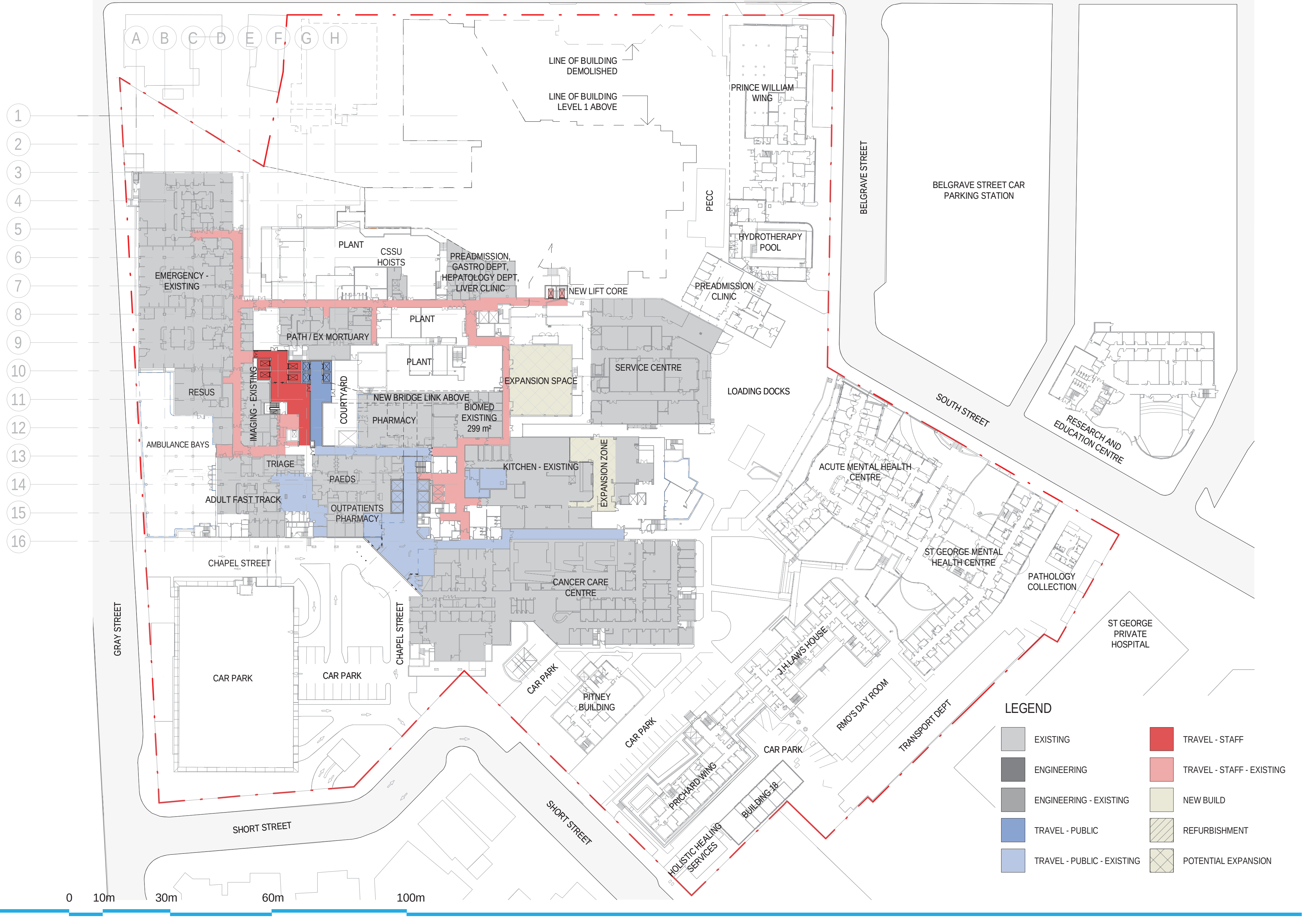
NB00043-ECA-DG-10002

Masterplan - Basement

Scale : 1 : 1000

ST GEORGE HOSPITAL

MASTER PLANNING



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Masterplan - Ground Floor

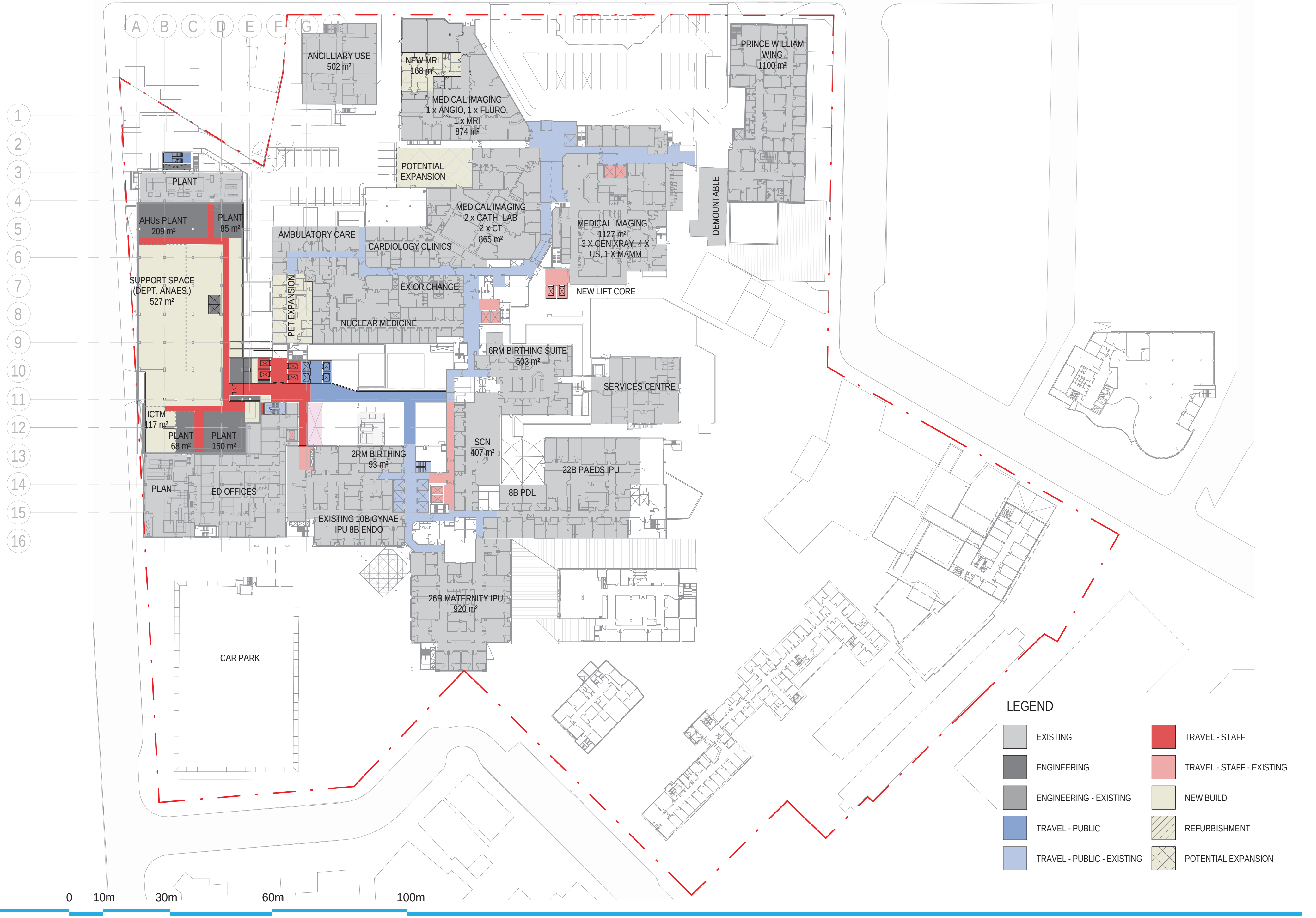
Scale : 1 : 1000

JACOBS

NSW Health Infrastructure

ST GEORGE HOSPITAL

MASTER PLANNING



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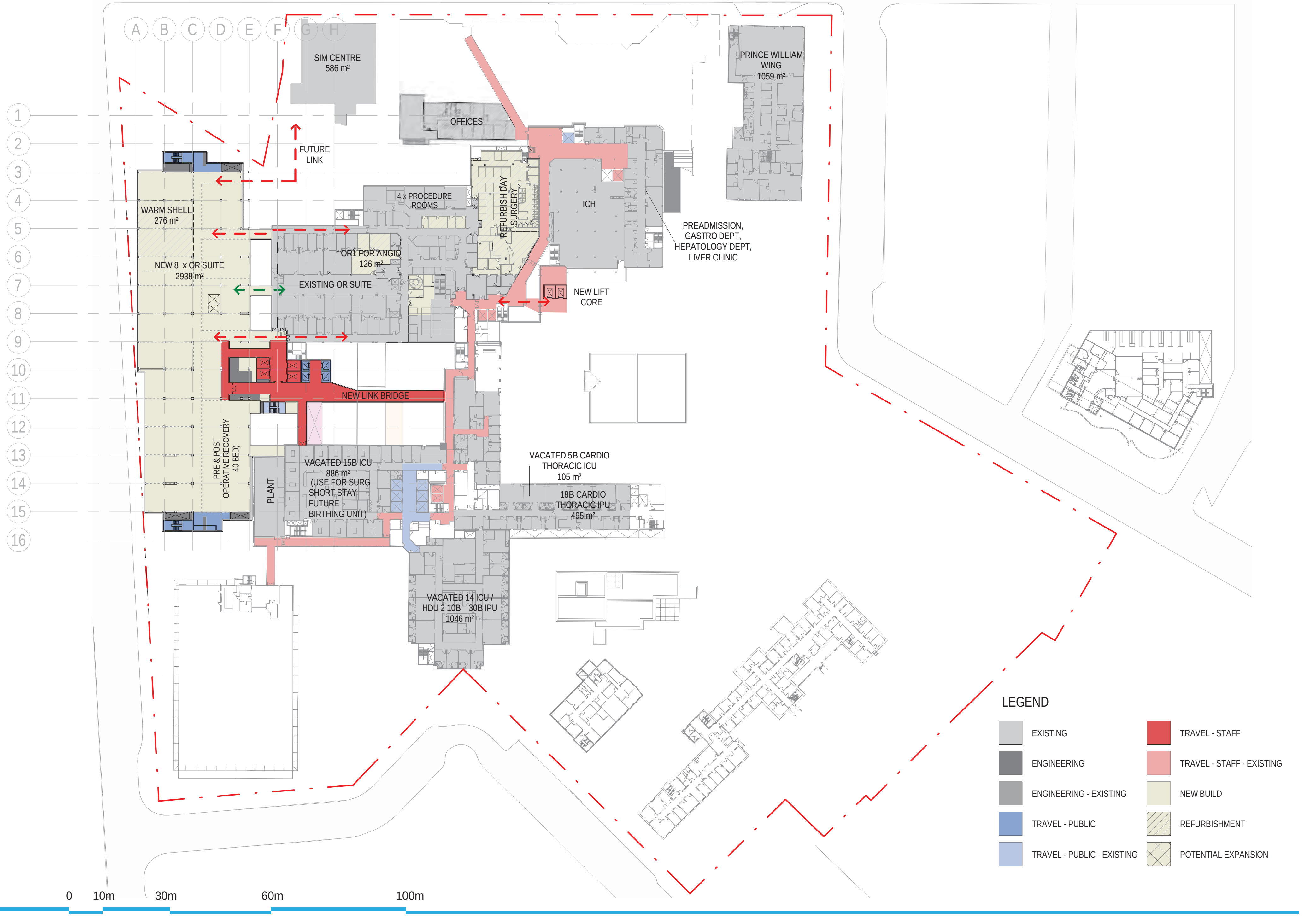
NB00043-ECA-DG-10004
Masterplan - Level 1
Scale : 1 : 1000

JACOBS

NSW Health Infrastructure

ST GEORGE HOSPITAL
MASTER PLANNING



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Masterplan - Level 2

Scale : 1 : 1000

JACOBS

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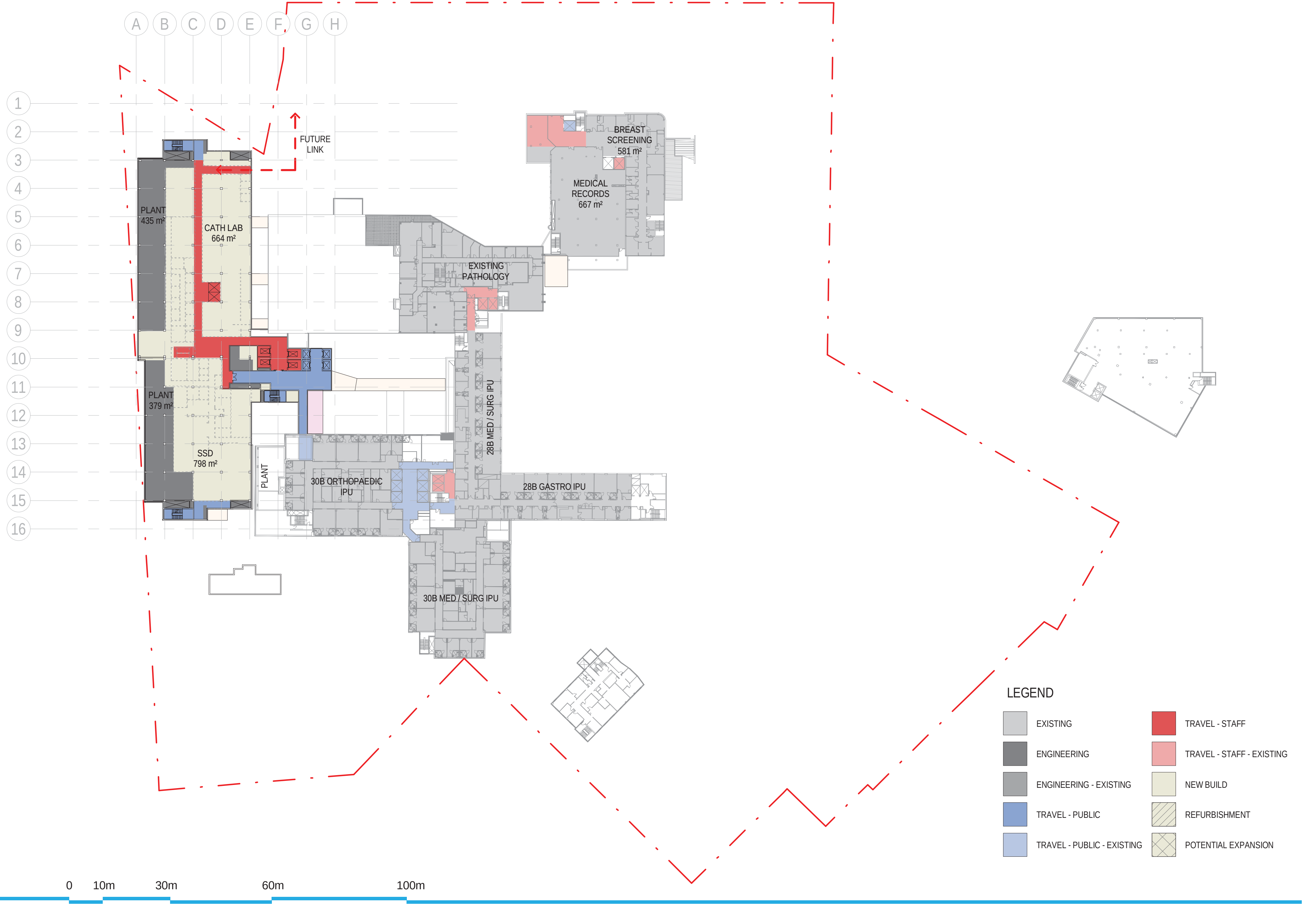
ST GEORGE HOSPITAL

MASTER PLANNING



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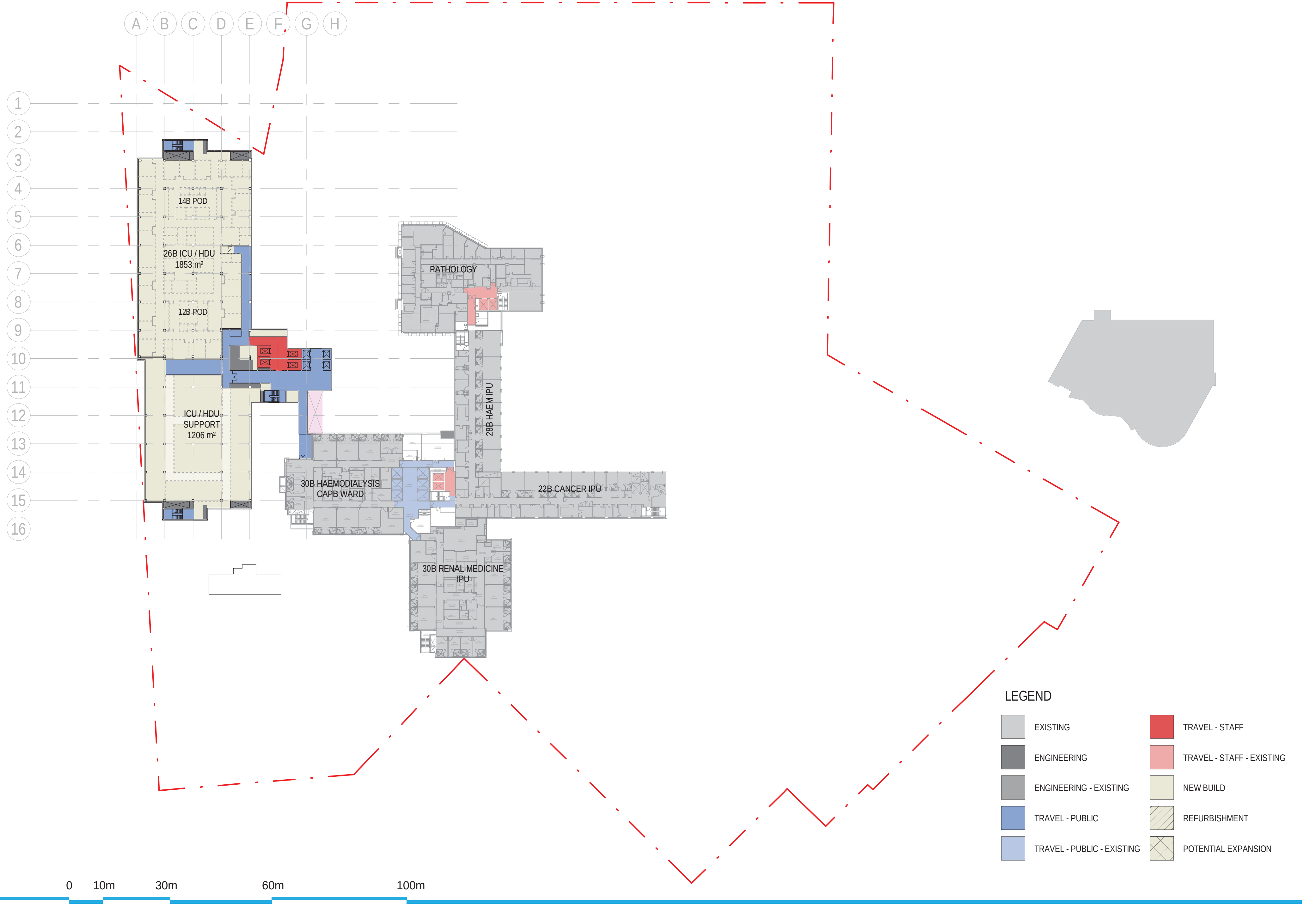
Masterplan - Level 3
Scale : 1 : 1000

JACOBS

NSW GOVERNMENT Health Infrastructure

ST GEORGE HOSPITAL
MASTER PLANNING



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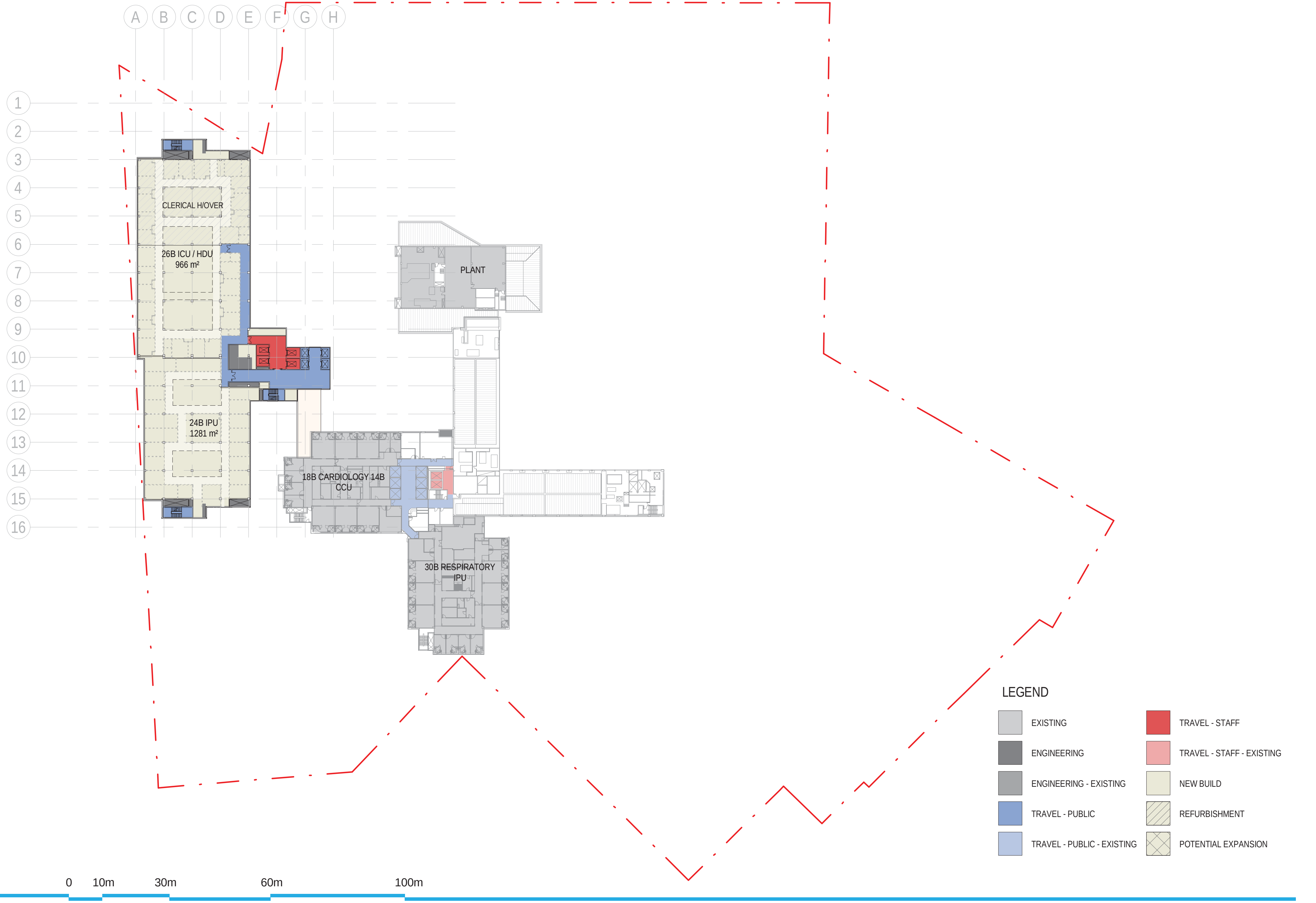
NB00043-ECA-DG-10007
Masterplan - Level 4
Scale : 1 : 1000

JACOBS

NSW GOVERNMENT Health Infrastructure

ST GEORGE HOSPITAL
MASTER PLANNING



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NB00043-ECA-DG-10008

Masterplan - Level 5

Scale : 1 : 1000

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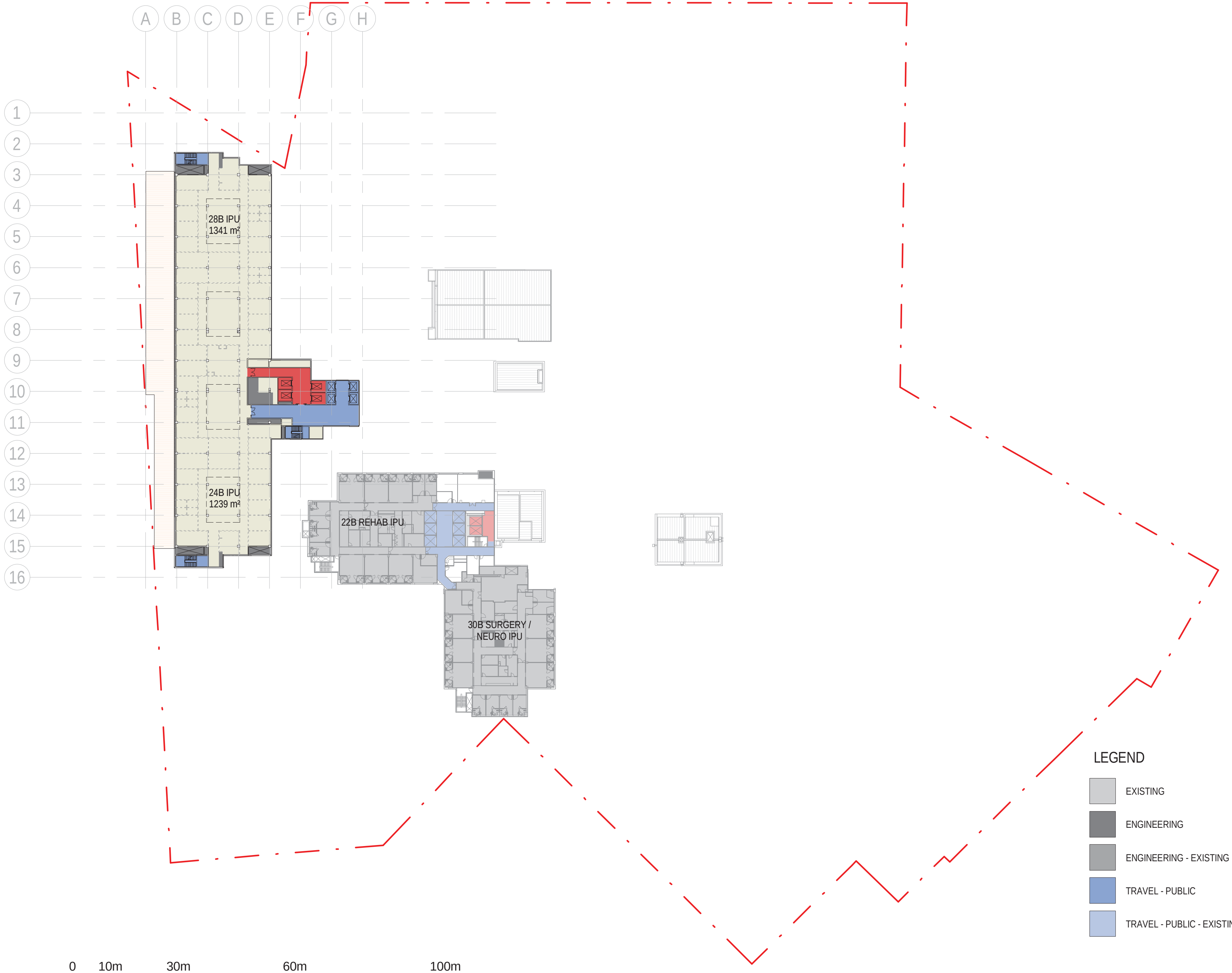
NSW Health Infrastructure

ST GEORGE HOSPITAL

MASTER PLANNING



LEGEND

EXISTING	TRAVEL - STAFF
ENGINEERING	TRAVEL - STAFF - EXISTING
ENGINEERING - EXISTING	NEW BUILD
TRAVEL - PUBLIC	REFURBISHMENT
TRAVEL - PUBLIC - EXISTING	POTENTIAL EXPANSION

0 10m 30m 60m 100m

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NB00043-ECA-DG-10009

Masterplan - Level 6

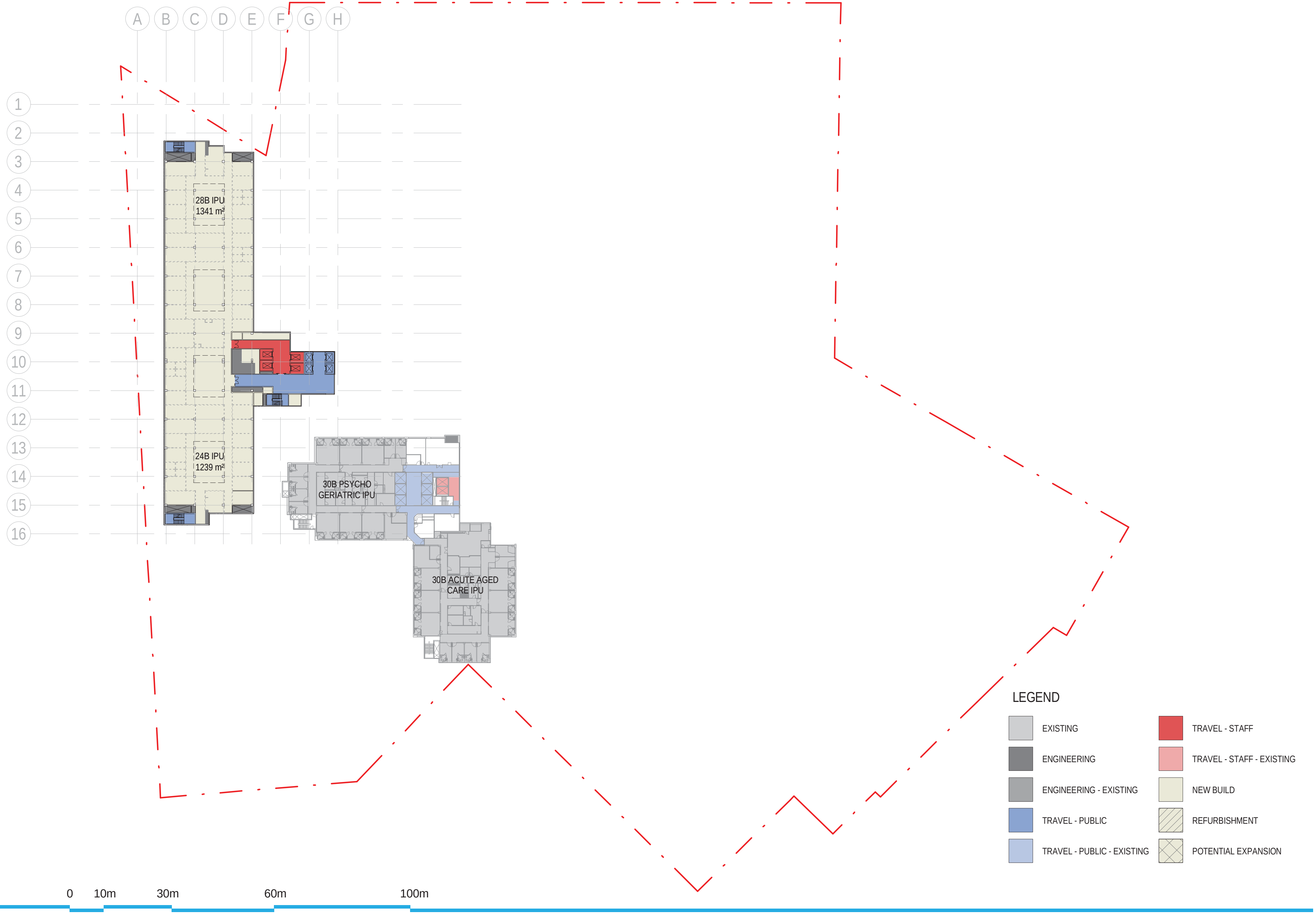
Scale : 1 : 1000

JACOBS

NSW GOVERNMENT Health Infrastructure

ST GEORGE HOSPITAL

MASTER PLANNING



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NB00043-ECA-DG-10010

Masterplan - Level 7

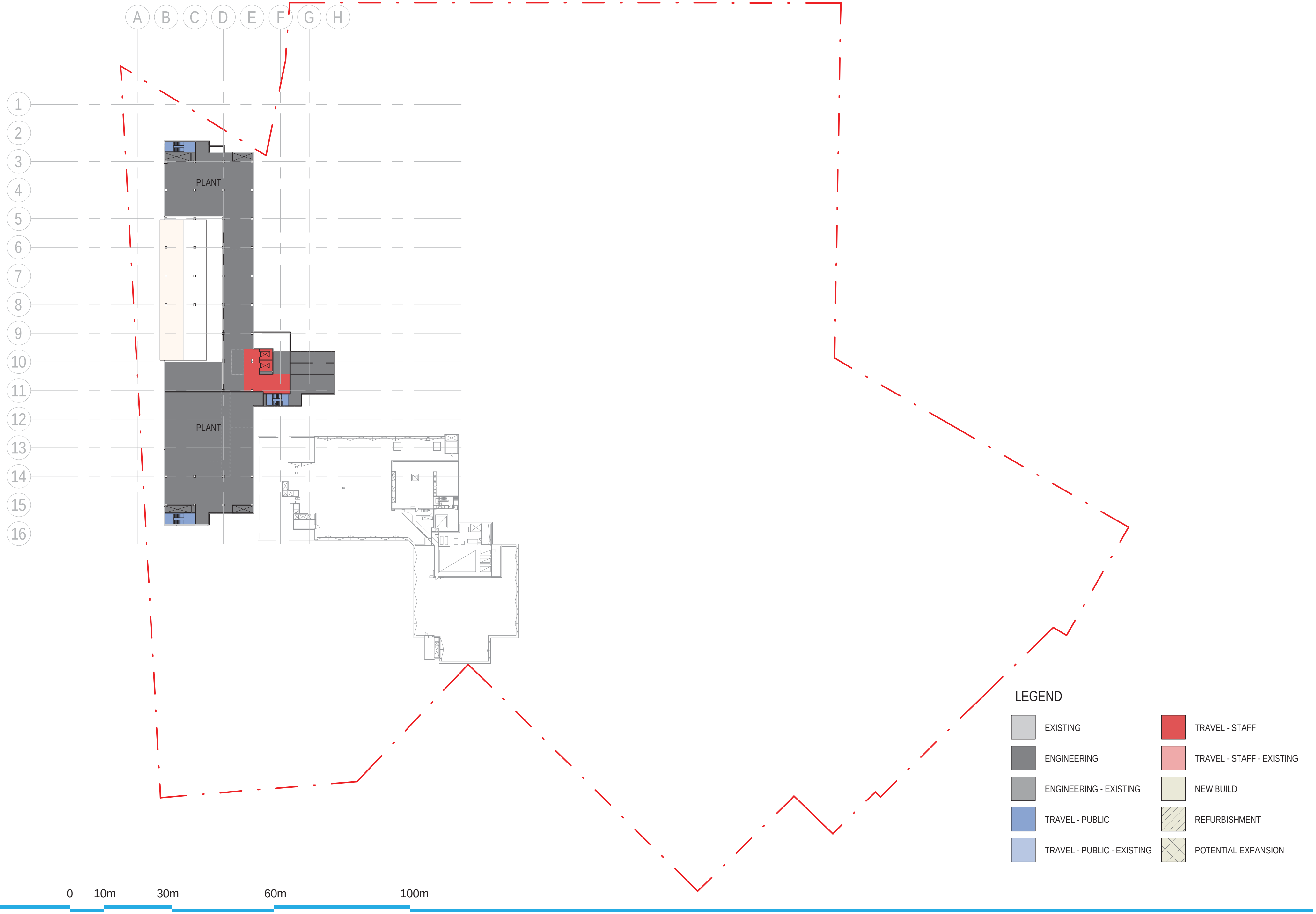
Scale : 1 : 1000

JACOBS

NSW GOVERNMENT Health Infrastructure

ST GEORGE HOSPITAL

MASTER PLANNING



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NB00043-ECA-DG-10011

Masterplan - Level 8

Scale : 1 : 1000

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ST GEORGE HOSPITAL

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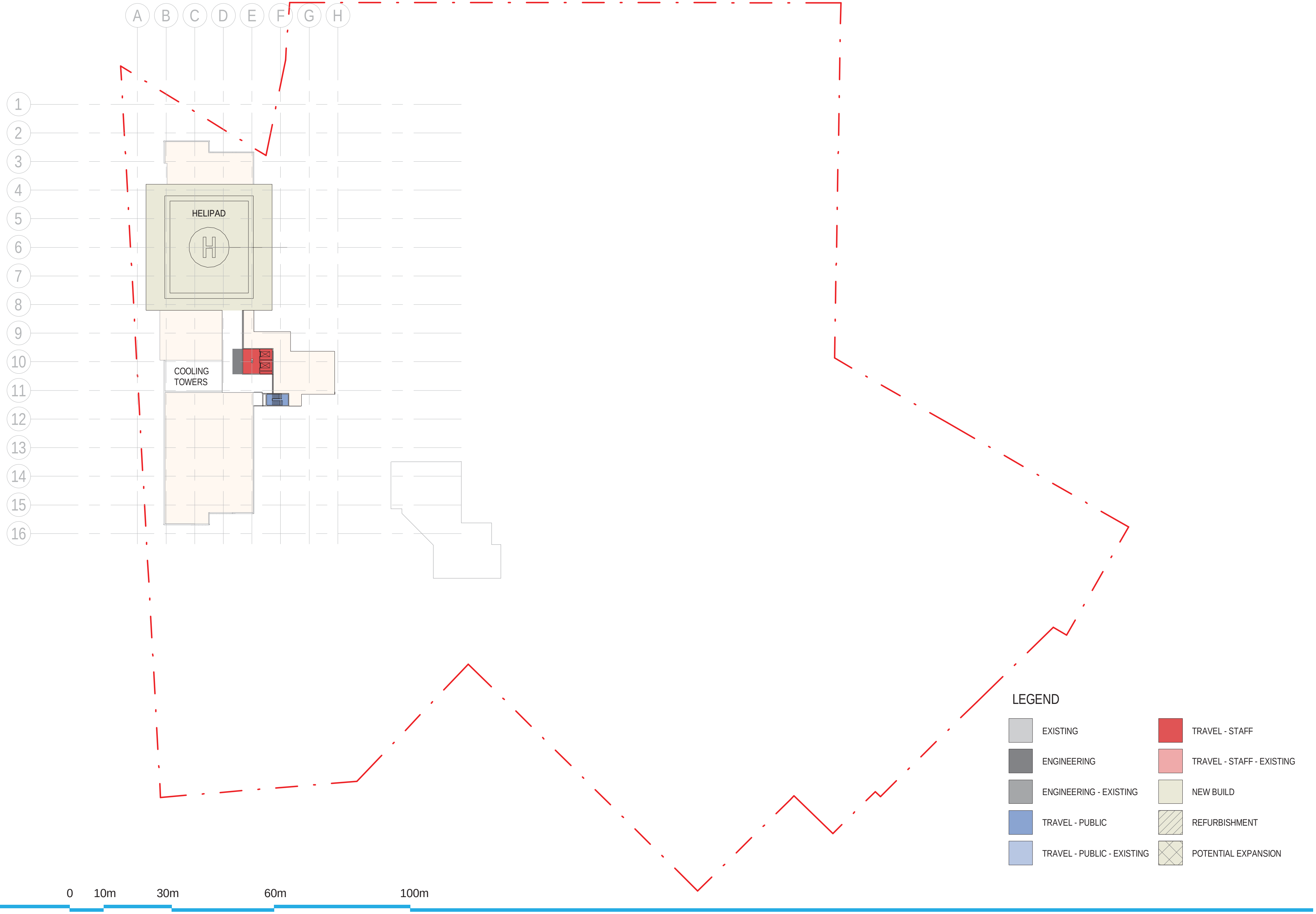

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NB00043-ECA-DG-10012

Masterplan - Level 9

Scale : 1 : 1000

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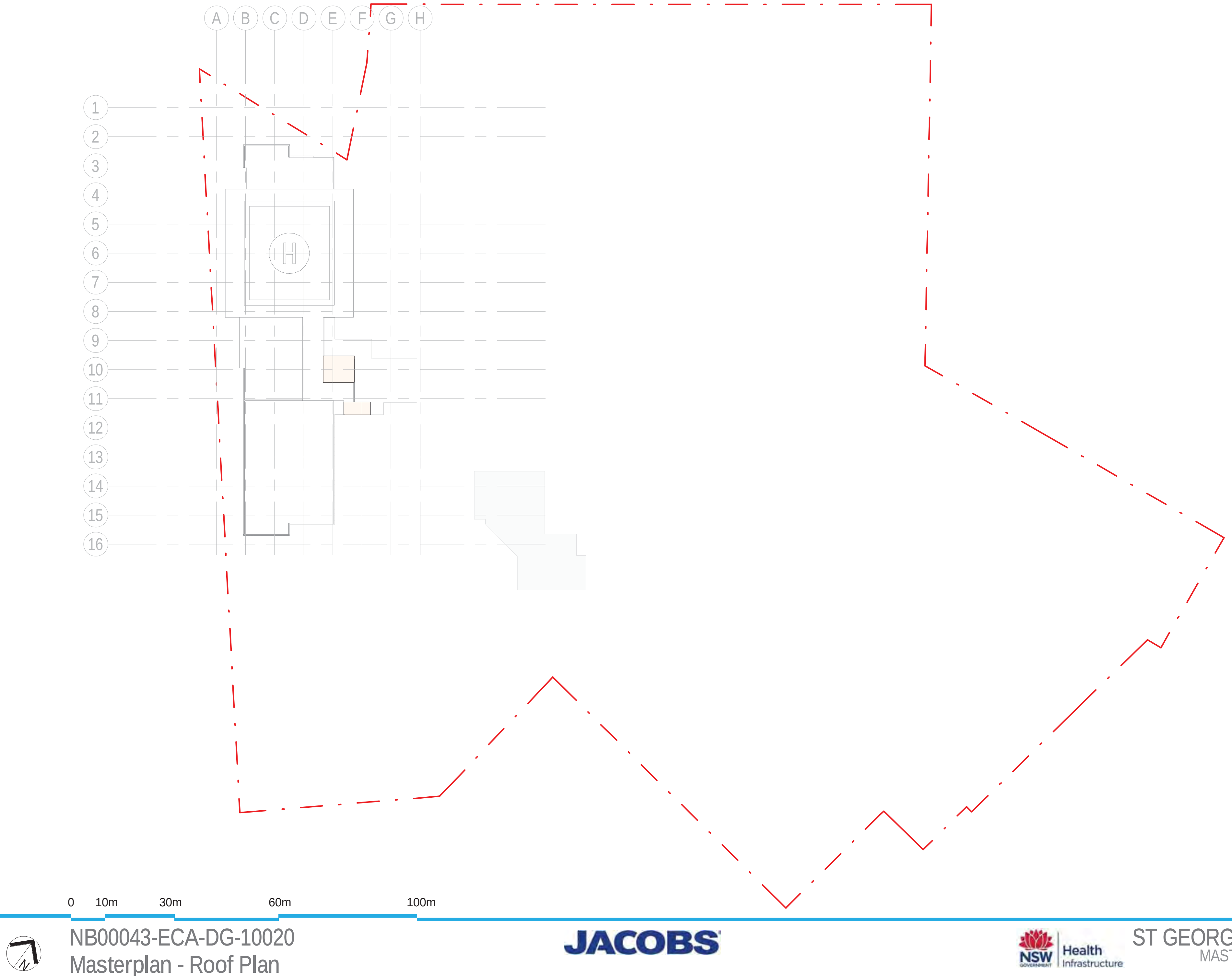
NSW Health Infrastructure

ST GEORGE HOSPITAL

MASTER PLANNING



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NB00043-ECA-DG-10020

Masterplan - Roof Plan

Scale : 1 : 1000

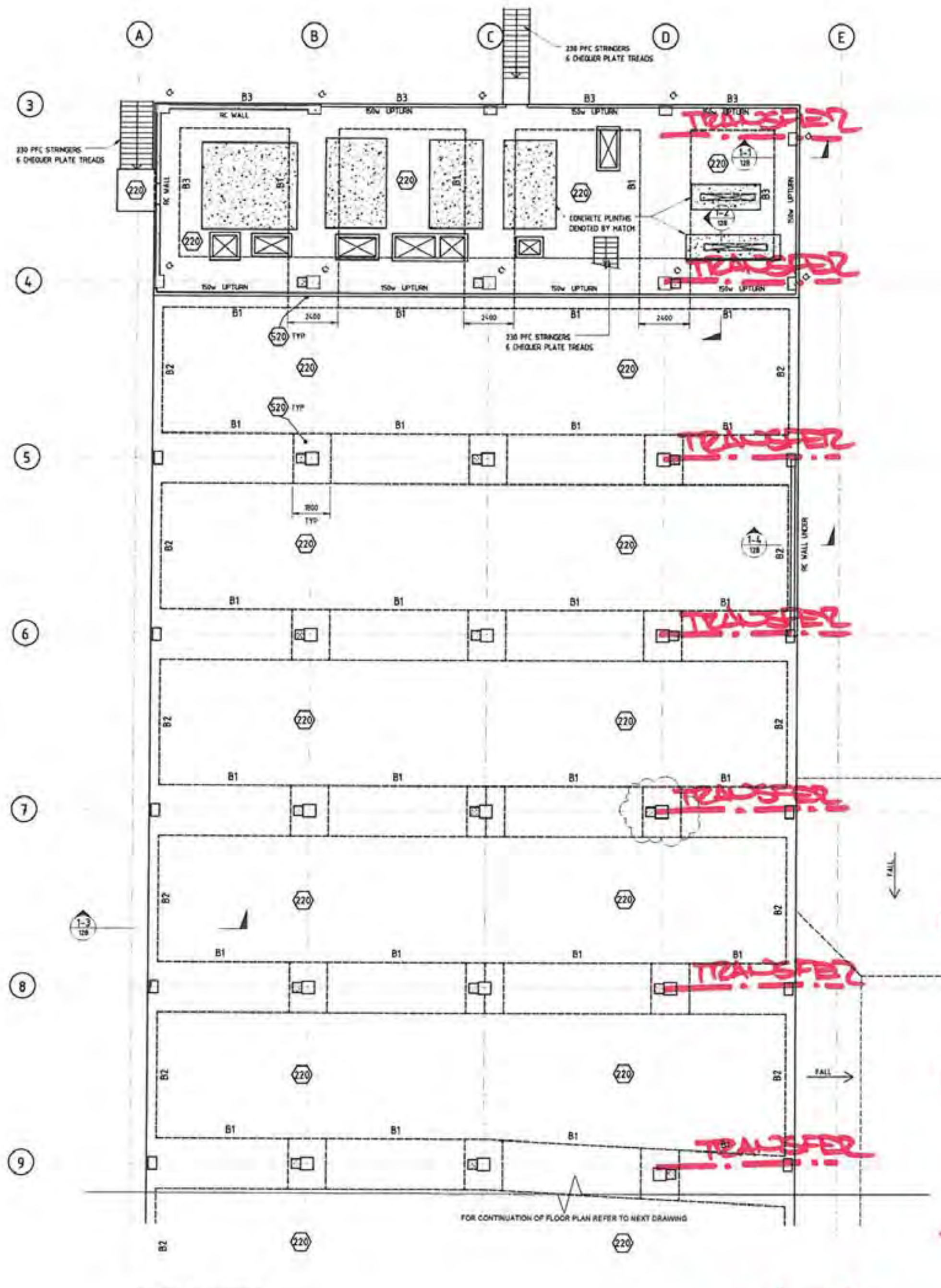
JACOBS

NSW GOVERNMENT Health Infrastructure

ST GEORGE HOSPITAL

MASTER PLANNING

FOR GENERAL NOTES REFER TO DRAWING SGHED-S-100



LEVEL 1 - NORTH

SCALE 1:100

COLUMN SCHEDULE			
MARK	DESCRIPTION	SIZE (W x D)	F'c (MPa)
C1	ED COLUMN	600 x 600	50
C2	ED COLUMN	400 x 600	50
C3	ED COLUMN	300 DIA.	50

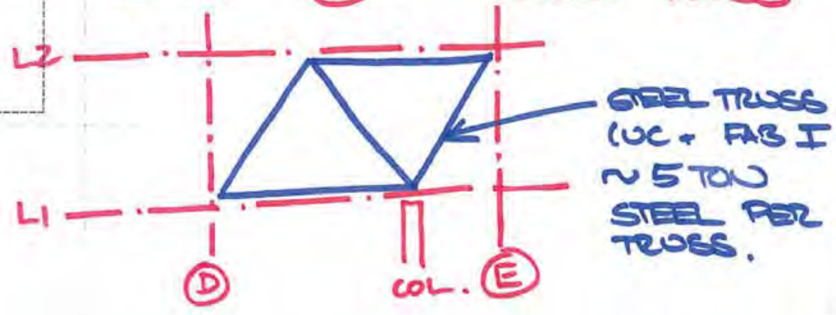
CONCRETE BEAM MEMBER SCHEDULE	
MARK	SIZE (W x D)
B1	2400w x 420d
B2	450w x 420d
B3	1200w x 420d
B8	900w x 420d
B10	600w x 720d
B11	1850w x 420d
B12	1600w x 420d
B13	1500w x 520d

NOTES:
ALL STAIR WALLS TO BE 190 THICK REINFORCED CONCRETE U.N.O.
ALL LIFT WALLS TO BE 190 THICK REINFORCED CONCRETE U.N.O.
ALL RC WALLS TO BE 190 THICK U.N.O.
150 WIDE UPTURN HEIGHTS TO ARCHITECTS SPECIFICATION
75 MINIMUM TOPPING SLAB WHERE ARCHITECT SHOWS OVER LEVEL 1 SLABS. SL82 MESH. FALLS TO ARCH. SAWN JOINTS AT MAX 5m CTS.
SETDOWN LOCATIONS IN TOPPING SLAB REFER TO ARCHITECTS DRAWINGS
DENOTES AREA OF BEAM ZONED REINFORCEMENT FREE

TRANSFER STRUCTURE

OPTION ① - P/T BEAM.
- 1300 (D) x 2400 (W)
f'_c = 50MPa
1500kg REO PER BEAM
1000kg P/T PER BEAM.

OPTION ② - STEEL TRUSS



NE CORNER FLR CANTILEVER
PRELIM TRANSFER REQUIREMENTS

13/08/14

NORTH ZONE

C3 CONSTRUCTION ISSUE
C2 REINFORCEMENT FREE ZONES AMENDED
C1 CONSTRUCTION ISSUE

QA CHECK

ST GEORGE HOSPITAL
EMERGENCY DEPARTMENT

NSW Health Infrastructure

TRUE NORTH
PROJECT NORTH

HEALTH PROJECTS INTERNATIONAL

USE FIGURED DIMENSIONS ONLY. DO NOT SCALE. ALL DIMENSIONS SHALL BE VERIFIED ON SITE AND DISCREPANCIES IMMEDIATELY BROUGHT TO THE ATTENTION OF THE PROJECT MANAGER FOR RESOLUTION

"CLOUDS" & REVISIONS ARE INTENDED AS GUIDES AND NOT NECESSARILY DESCRIBE THE FULL EXTENT OF REVISIONS. ASCERTAIN FULL EXTENT BY COMPARISON WITH PREVIOUS VERSION

Cardno Shaping the Future

AcOR

sweett

LEVEL 1 PLAN - NORTH ZONE

REVIT 2012 SGHED-S-120 C3