Achieving N+1 Redundancy for ADHB's Sitewide Services

Presenting: Waren Warfield

Construction Clients' Group
CONSTRUCTING EXCELLENCE

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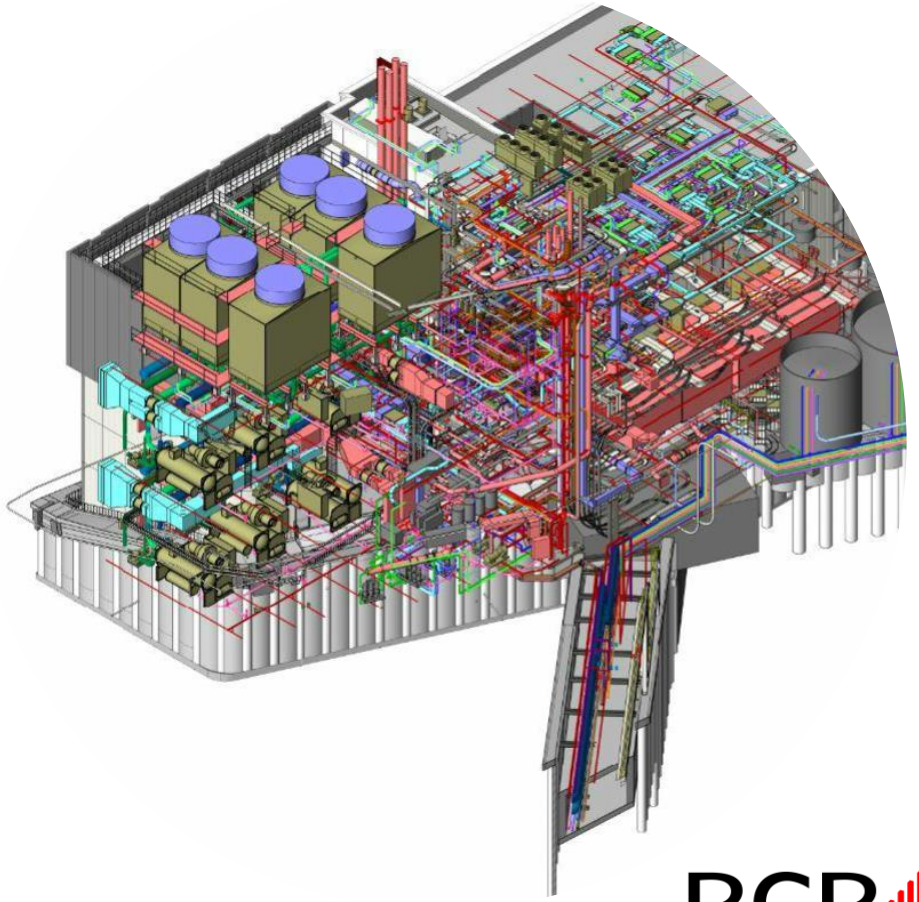
Central Plant and Tunnel

Critical Hospital Infrastructure



Key Objectives & Principles

Continuity of Service in a Tertiary Level Hospital Environment

The purpose of the new Central Plant and Tunnel project, is to provide a resilient central facility to house the majority of the campus infrastructure to replace the old and existing central plant facilities.

What did this mean for the new Central Plant and Tunnel project?

- Allowing the site to operate for 72 hours without relying utilities and truck deliveries for key life safety services.
- 100-year design life, IL4 Building (with low damage design) – must be operational after a major incident e.g., Seismic Event.
- N+1 Redundancy – no single points of failure.
- Safety in Design, Construction, Maintenance and ongoing operation.
- Safety in commissioning, integration and migration from the existing central plant to the new Central Plant

N+1 Design

What does this mean?

N+1 redundancy means the hospital operation will not be disrupted by a single component being out of service due to maintenance, failure or other significant events. All systems will run at full capacity in an event that affects a single component.

To contrast, N redundancy means the hospital operational will be distributed by a single component being out of service due to maintenance, failure or other events. The service will remain operational however, but with reduced capacity.

Examples of what this meant for the Central Plant and Tunnel Project are:

- Main electrical supplies, main switchboards and submains to major distribution board shave N+1 redundancy. Space was allocated for future expansion.
- Chilled water plant N+1 redundancy.
- Heating and chilled secondary water pumps N+1 redundancy.
- Communications and fibre routes N+1 redundancy.
- Provisions for capacity in the new system to cater for maintenance activities e.g., either of the 2 generators has capacity to cover the whole essential site load, as well as plug-in generator points were provided.

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Key Design Outcomes

The Influence of N+1 and a 100-year Design Life

Examples of key outcomes directly attributable to adopting a N+1 redundancy and 100-year design life are:

- The inclusion of a secondary High Voltage incomer main from Vector and a watermain from Watercare on Grafton Road.
- The adoption of concrete in lieu of a steel frame from the primary structure of the new Central Plant building (less maintenance requirements and improved durability).
- The adoption of base isolation for the new Central Plant building.
- The inclusion of a water treatment plant within the new Central Plant building and additional water storage facilities (fire fighting and potable water).
- The inclusion of a campus wide services control room.
- The separation of dry and wet infrastructure with the new Central Plant Building.
- The separation of the communication routes for redundancy.
- Increased storage capacity for diesel to cater for the 72 hours of operations for the generators.

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Safety in Design – Approach

One Project, Two Parts

The Central Plant and Tunnel project is comprised of two distinct components that attract different risk profiles.

It was decided early in the design process that when Safety in Design was considered for this project, different approaches and different specialists would necessary. To this end, the project was split into two parts as follows:

1. Central Plant Building
2. Service Tunnels

What we looked at as a project team was the risks/hazards that would present themselves in both the Construction Phase and Operations Phase, and how they could be best mitigated through good design, construction methodology, site limitations and controls.

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Central Plant Building (A40) – Construction Phase

Safe in Design

RISK REGISTER: 1.Construction (A40 building)

Version: 5.0 Revised Aug 19 **Issued: Mar 21**

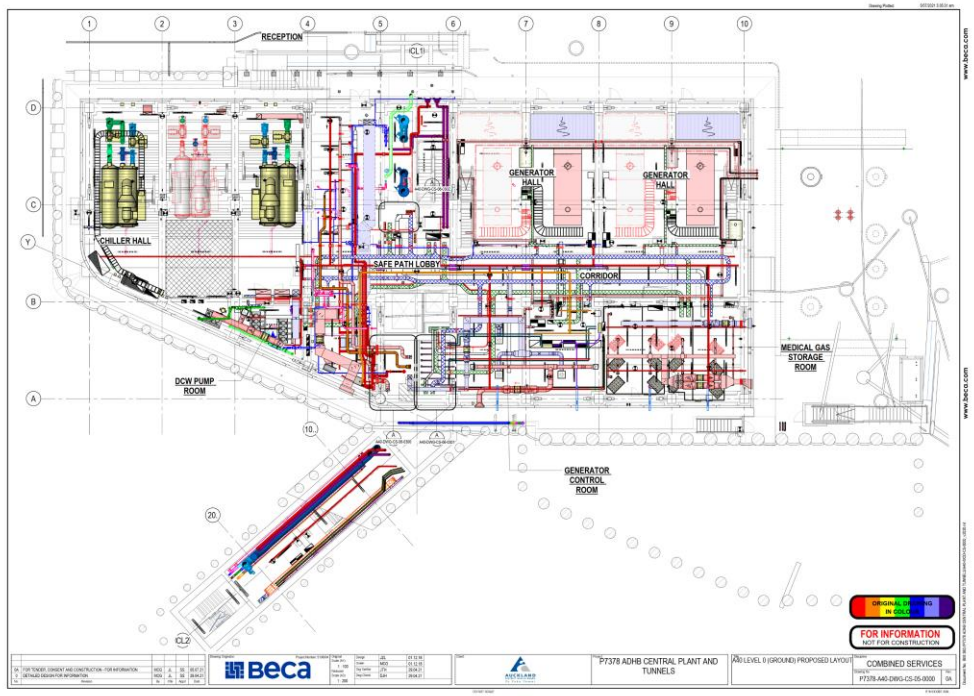
Project name / number: P7378 Central Plant and Tunnels

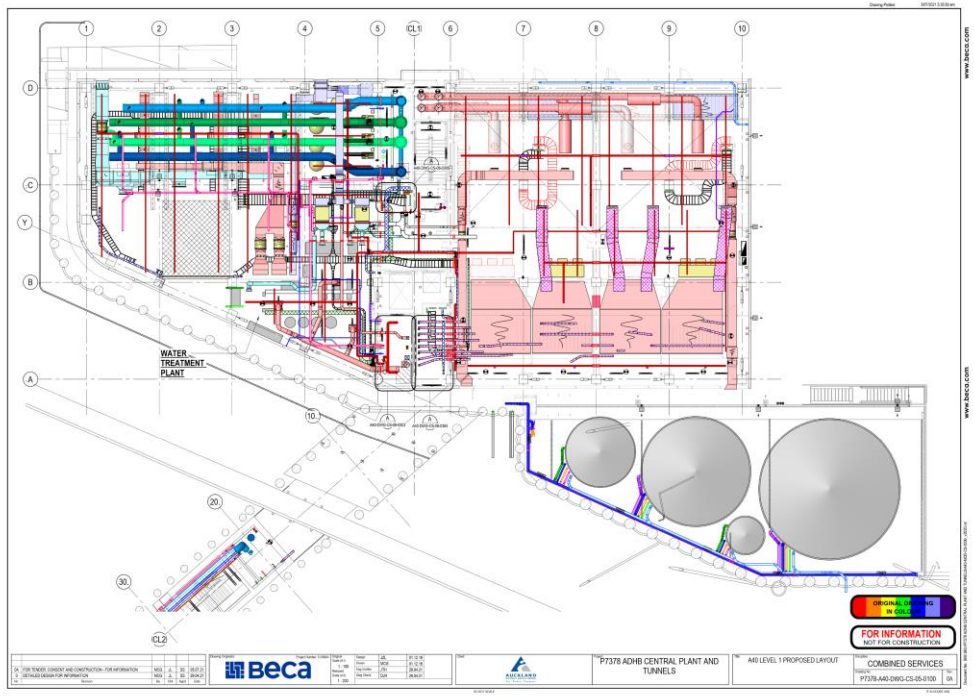
Ref ID #	Action Owner	Risk Description	Impact	Risk Category	Risk Assessment				Design Control(s)	Additional Control(s) required + heirachy & description	Risk Status (After treatment)				Risk Owner	Review Date	Open / Closed
					Likelihood	Consequence	Risk Score	Risk rating (RAG)			Likelihood	Consequence	Risk Score	Revised risk rating (RAG)			
A40 C1	PM	Site access; working within an existing operational hospital Keeping pedestrian & vehicle, fire service access, fire egress routes open. Note Mental Health unit nearby so enhanced measure to control site will be important	Potential injury / harm to public	1. Egress / Access	3	3	9		Construction staging methodology is being considered in conjunction with Flow (traffic management consultants). Pedestrian and (restricted) vehicle access intended to be maintained through use of temporary bridging.	Consider securtiy provisions wrt SOPs working near the Mental Health facility	1	3	3		PM/ Contractor	25/02/2021	open
A40 C2	PM/ contractor	Construction / excavation up to & against existing structures (A01, A06, A11, existing retaining wall). Unknown existing structure conditions	Existing building collapse	1. Load / Force / Energy	2	4	8		Investigations and settlement assessments for existing buildings are being carried out as part of PD to further assess risk. Outputs to feed into design + construction methodology considerations.	DTeam have moved piling away from A11 as far as possible. Consider adjacent windows may need blocking. Seeking as builts for A11 if not avail may need to survey and pot hole investigate	1	4	4		PM/ Contractor	25/02/2021	open
A40 C3	PM/ contractor	Cranage / propping / handling precast Heavy lifting of precast elements; beams; double tees; cladding panels	Potential injury / harm to workers	1. Load / Force / Energy	3	3	9		* Concrete required for durability and standard precast practice applies. Precast versus in-situ will be considered as part of design development. * Consider location of cranes, lifting areas (stability and proximity to overhead powerlines if any).	Method to include avoid lifitng over active roads	2	3	6		PM/ Contractor	25/02/2021	open
A40 C4	PM/ contractor	Stability of temporary construction loading conditions	Harm to workers	1. Load / Force / Energy	2	4	8		Contractor to ensure temporary propping is designed during construction stage	Monitor ground conditons to validate design assumptions during construction	1	4	4		PM/ Contractor	25/02/2021	open
A40 C5	PM/ contractor	Installing services at U/S of floor level	Potential fall, and/or harm to worker from failing objects	1. Heights / Depths	3	3	9		Provide EWP for installation of any overhead objects and/or scaffolding	none	1	3	3		PM/ Contractor	25/02/2021	open
A40 C6	PM/ contractor	Deep excavations and working inside deep excavations	* Potential loss of critical services: electrical; medical gases; water; cooling injury to workers; * Potential Fall; Confined Space Hazards;	1. Heights / Depths	3	4	12		* Site surveying completed to mitigate risk of unknown in-ground services. Review of survey outputs with ADHB facilities and incumbent contractors to feed in site IP. Provision of additional plug in points for standby chillers, generators. Services diversions and/or retain and protect strategies being implemented as part of design development. * Provide adequate shoring, batter, and/or trenches as required, access ladder/scaffolding into the excavation; Provision of ventilation, management of possible gases, and appropriate controls in working inside confined spaces.		1	4	4		PM/ Contractor	25/02/2021	open
A40 C7	PM/ contractor	Large diameter pile holes left open during construction.	Potential fall	1. Heights / Depths	2	4	8		Pile hole to be covered over with mesh and ply to protect worker from fall.		1	4	4		PM/ Contractor	25/02/2021	open
A40 C8	PM/ contractor	Underground services Protection of services	Potential loss of critical services: electrical; medical gases; water; cooling injury to workers	1. Utilities/Services	3	3	9		Site surveying completed to mitigate risk of unknown in-ground services. Review of survey outputs with ADHB facilities and incumbent contractors to feed in site IP. Provision of additional plug in points for standby chillers, generators. Services diversions and/or retain and protect strategies being implemented as part of design development.	Have enagged additional investigation works beyond std survey e.g CCTV, *pot holing, hydrovac trenching etc, pressure test valves	1	3	3		PM/ Contractor	25/02/2021	open
A40 C9	PM/ contractor	Movement and handling of heavy plant	Injury, ergonomics	1. Load / Force / Energy	3	3	9		Sufficient pathway (width and height) and lifting provisions provided (ground stability and proximity to overhead powerlines if any)	DT have engaged early advice with machinery handlers specialists, have reviewed road levels to assist. Provision of winching points wil be included in design	1	3	3		PM/ Contractor	25/02/2021	open
A40 C10	NDY/ contractor	Construction noise	harm to public, staff and workers	1. Construction	2	3	6		NDY - Tim. Design suitable to limit noise. Regular audits. Choose low noise plant. Timing for noisy works, site noise monitoring	Time works to limit impact. Minimise on site cutting, locate noisy work in acoustic shelter where possible	2	2	4		PM/ Contractor/ NDY	25/02/2021	open
A40 C11	PM/ contractor	Working at height (double height A40 spaces)	Falls, injury	1. Heights / Depths	3	4	12		Use of platform ladder, elevated mobile platform, scaffolding		1	4	4		PM/ Contractor	25/02/2021	open

P7378.1.9.SiD.Working File Feb 2021

Central Plant Building (A40)

Design Configuration (Wet/Dry Separation and Operational Clear Space)





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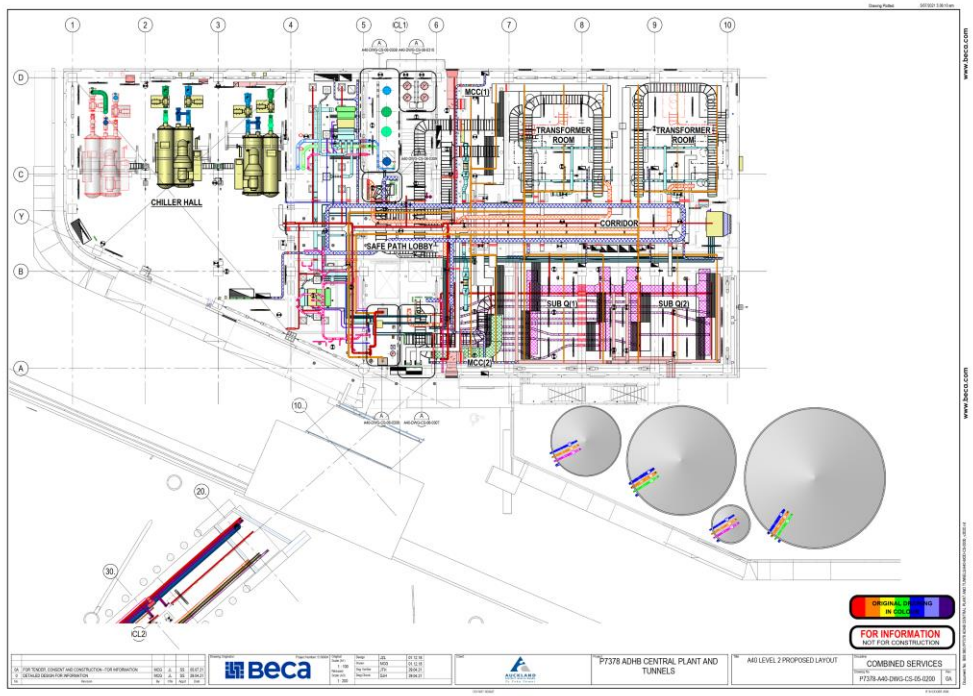

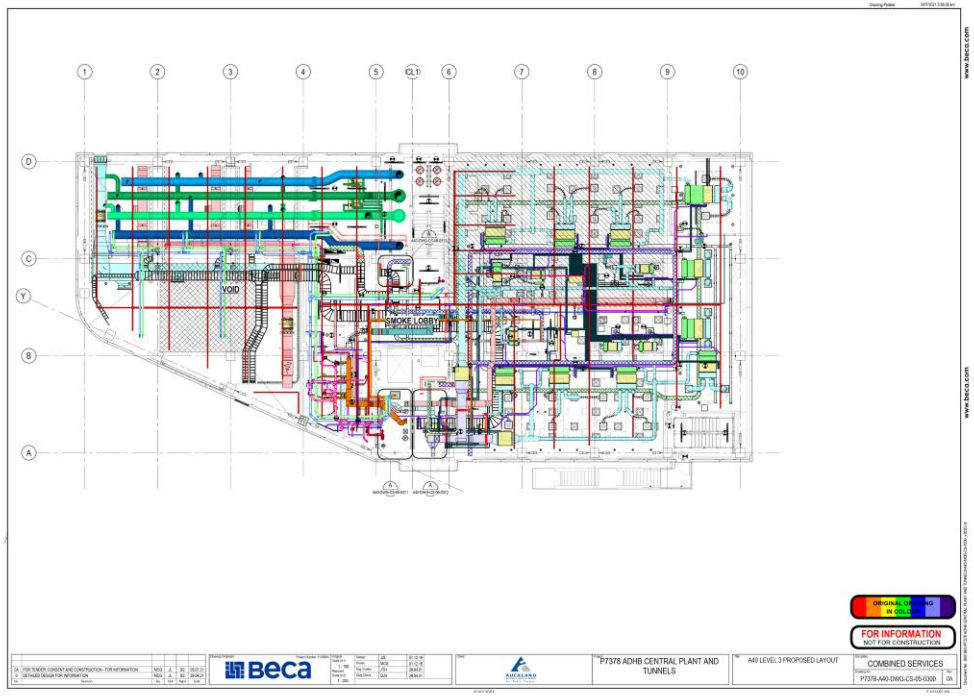

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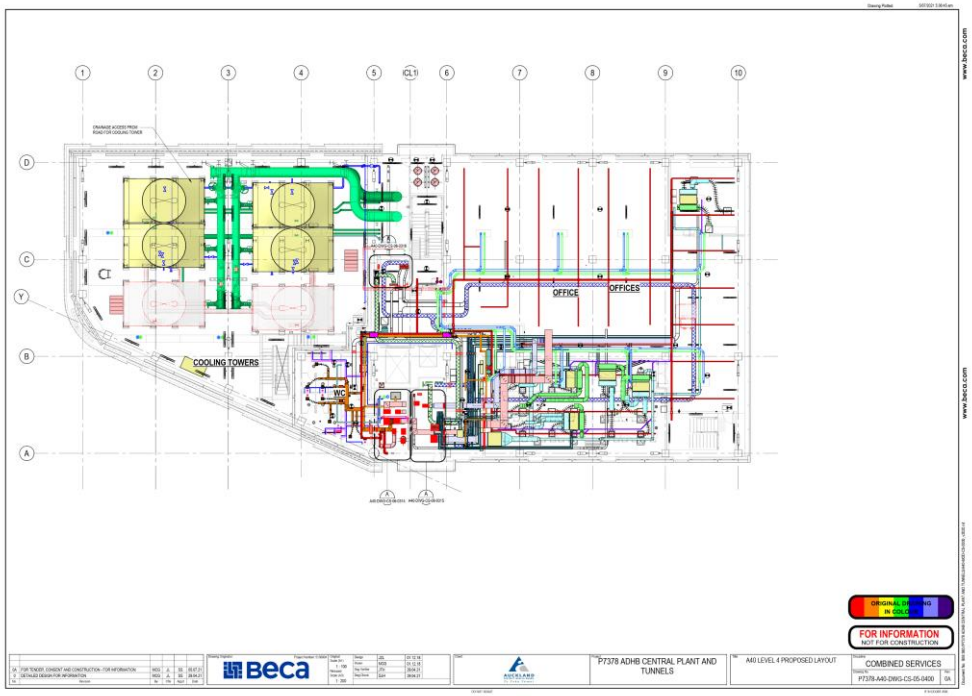

Central Plant Building (A40) – Operations Phase

AUCKLAND DISTRICT HEALTH BOARD
Te Toka Tumai

Safe in Design

RISK REGISTER: 2.Ops-Maintenance (A40 building)

Ref	Risk Description	Impact	Risk Assessment				Existing Control(s)	Additional Control(s) required + heirachy &					Risk Owner	Review Date	Open / Closed
			Likelihood	Consequence	Risk	Risk			Likelihood	Consequence	Risk	Risk			
A40 o1	Building cleaning Windows, general façade	Working at height; risk of falling; objects falling on people below	3	4	12		Provision of abseil (appropriate placement of abseil points from building edge)		1	4	4		PM/ design team	25/02/2020	open
A40 o2	Façade maintenance; glass replacement from outside; louvres; painting	Working at height; risk of falling; objects falling on people below	3	4	12		Investigate if glazing can be replaced from the inside rather than external access required. Provision of abseil (appropriate placement of abseil points from building edge)		1	4	4		PM/ design team	25/02/2020	open
A40 o3	Roof maintenance	Working at height; risk of falling; objects falling on people below	3	4	12		Limit access to authorised personnel Provision of compliant barriers with Parapets		1	4	4		PM/ contractor	25/02/2020	open
A40 o4	Maintenance of internal building fabric particularly in double height spaces - includes; ceiling and wall linings; structural steel braces intumescent & protective coatings; secondary steel protective coatings	Working at height; risk of falling; objects falling on people below	3	4	12		In double height spaces - use a scissor lift or mobile scaffolding where floors are clear of plant, otherwise allow to scaffold over and around plant. Majority of basis accessible from internal, intumescent coating hardened will be specified to reduce maintenance regularity		1	4	4		PM/ design team	25/02/2020	open
A40 o5	Floor coverings general; on-going maintenance	Slips, trips, falls; injury / harm to building users	2	2	4		N/A	Carry out regular inspections to ensure junction are remaining flush; Ensure future refurbishments are code compliant	1	2	2		PM/ BAU team	25/02/2020	open
A40 o6	Stairs & ramps - floor coverings; on-going maintenance	Slips, trips, falls; injury / harm to building users	2	2	4		Carry out regular inspections to ensure junction are remaining flush; Ensure future refurbishments are code compliant		1	2	2		PM/ BAU team	25/02/2020	open
A40 o7	Noise from central plant	Hearing loss &/or general annoyance of servicemen & office users	2	3	6		Acoustic control - consider adding attenuation to equipment which is noisier than the primary equipment located in the room. i.e Vent fans under normal operation should not require hearing protection. Use of fire alarm light strobe for noisy rooms. Good acoustic design		1	2	2		PM/ design team	25/02/2020	open
A40 o8	Exposure to EMF from electrical switches & boards	General harm from exposure to EMF	3	3	9		Provision of building perimeter earthing and Wricon connection to building structure's rebar		1	3	3		PM/ design team	25/02/2020	open
A40 o9	Ventilation of medical gases store room	Explosion, exposure to hazardous gases	2	4	8		Provision of ventilation system in accordance to Hazardous Substance Regulations		1	3	3		PM/ design team	25/02/2020	open
A40 o10	Services, lighting maintenance within double height spaces	Working at height; risk of falling; objects falling on people below	3	4	12		Mezzanine level for large chilled water valve access. Lights located at accessible height utilising scissor lift, elevated work platform for access. Refer also previous item on considering actuated valves, chain actuated etc, consider uplighting. Spec long life equipment		1	4	4		PM/ design team	25/02/2020	open
A40 o11	General central plant replacement; moving large pieces of plant (up to 20,000kg) into; out of; & around the central plant building	Ergonomics, loads resulting in harm	3	3	9		Provide floor anchor points for manouvring plant on rollers; provide permanent gantries for manouvring heavy items (includes gantry for lowering chillers between upper to lower chiller halls) Provide adequate working space around plant and building access route.		1	3	3		PM/ design team	25/02/2020	open
A40 o12	Working around large floor access hole in upper chiller hall floor - for plant access to lower level	Working at height; risk of falling; objects falling on people below	2	4	8		Provide hazard markings on floor 1000mm back from edge; provide anchors for installation of temporary barriers when hole is open; provide harness points for personnel and lifting points for taking out the hatches		1	4	4		PM/ BAU team	25/02/2020	open

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Service Tunnels – Construction Phase

AUCKLAND DISTRICT HEALTH BOARD Te Toka Tumai

Safe in Design

RISK REGISTER: 1.Construction (Tunnel)

Version: 5.0 Revised Aug 19 **Issued: March 2021**

Project name / number: P7378 Central Plant and Tunnels

Ref ID #	Action Owner	Risk Description	Impact	Risk Category	Risk Assessment				Existing Control(s)	Additional Control(s) required + heirachy & description					Risk Owner	Review Date	Open / Closed
					Likelihood	Consequence	Risk Score	Risk rating (RAG)			Likelihood	Consequence	Risk Score	Revised Risk rating (RAG)			
TC01	PM/ design team	Tunnel alignment - Construction is located within public areas that need to remain open for the hospital to remain functional. Refr also A40C1	Risk to public of location of tunnels	1. Construction	1	4	4		Alignment chosen considers existing access (ped and Vehicle). Bridges incorporated into the concept design to keep road open. Refer also A40c1	Construction areas taken for works and consideration of interaction with hospital users.	1	4	4		PM/ Contractor	11/03/2021	open
TC02	PM/ design team	Tunnel construction from adjacent building A40. Consideration of interface of two separate work packages and concurrent construction works in tight areas. Risk of uncontrolled hazards from adjacent works sites (Controlled by another contractor)	Injury ranging from minor to fatality. Eg fall from height, plant vs. personel	1. Construction	3	4	12		Construction sequencing to be planned if A40 and tunnel are let as two different contracts interface management will be required. Note they Wont be let as two contracts	Further definition of the contracts and interface management by the client may be required. Currently planning 1 const package. Contractor to amange interfaces	2	4	8		PM/ Contractor	11/03/2021	open
TC03	PM/ design team	Tunnel/trench flooding	Drowning	1. Construction	2	4	8		Consideration of likely groundwater levels during and after construction in Temp and Permanent W design. Provision of drainage pumps, diversion of overland flows above excavation.	Drainage pumps and diversion to be included in design. Contractor to monitor weather if high risk rain event or weather alert	1	4	4		PM/ Contractor	11/03/2021	open
TC04	PM/ design team	Tunnel as confined space	Asphyxiation	1. Confined Spaces	3	4	12		Provision of adequate ventilation during construction, restricted access to trained personnel	Gas monitoring as necessary during construction. Access control and or peg board system. Method to include work with roof off. Design allows for this sequencing if contractro wishes to adopt method aorund that	1	4	4		PM/ Contractor	11/03/2021	open
TC05	PM/ design team	Unprotected existing services - heavy plant impact	Leak, explosion	1. Construction	2	3	6		Identification, location and protection of existing services, diversion through GPR site investigatiosn and diversions	Protective screens and barrier as well as stand over observation. Contigency measures avaliable during high risk works. Method to include acknowlegdemn of services	1	4	4		PM/ Contractor	11/03/2021	open
TC06	PM/ design team	Unprotected existing services - heavy plant impact	Loss of function to hospital services	1. Construction	2	4	8		Identification, location and protection of existing services, diversion through GPR site investigatiosn and diversions	Protective screens and barrier as well as stand over observation. Contigency measures avaliable during high risk works. Method to include acknowlegdemn of services	1	4	4		PM/ Contractor	11/03/2021	open
TC07	PM/ contractor	Structural adequacy of temporary works (propping)	Failure	1. Demolition	3	3	9			Contractor's QA, design, site supervision, independent checks specified in P&G and suitably qualified personnel	2	3	6		PM/ contractor	11/03/2021	open
TC08	PM/ design team	Use of large machinery, vehicles adjacent to excavation zones	Falling into excavation	1. Design / Specification	2	4	8		Temporary works design to allow for plant operations and loadings, and method of construction considered. Contractor machinery to be checked against design assumptions	Contractor's safety plan, appropriate machinery size, barrier and sufficient clearance, exclusion zones to be established	1	4	4		PM/ contractor	11/03/2021	open
TC09	PM/ design team	Excessive excavation depth	Collapse - death	1. Documentation / Other	3	4	12		Minimise depth through design and vertical shaft/stairs	Site review to check that dig is not too far	1	4	4		PM/ Contractor	11/03/2021	Open
TC10	PM/ design team/ contractor	Over excavation during construction	Over loading temporary works	1. Construction	3	4	12		Clearly document maximum allowable excavation depths (and stages of excavation eg propping). Undertake design with appropraite safety factors.	MSQA and instrumentation and monitoring of temporary works performance. check/redesign temporary support as necessary.	1	4	4		PM/ design team/ contractor	11/03/2021	open
TC11	PM/ contractor	Interactions between public and construction vehicles	Accident	1. Egress / Access	4	3	12		Client has outlined horading requirements and engaged on specific needs with stakeholders e.g Mental Health	Contractor's safety plan, barrier and sufficient clearance (stand down distances - vertical and horizontal)Additonal hoarding considering proximity of mental health facility	2	3	6		PM/ contractor	11/03/2021	open

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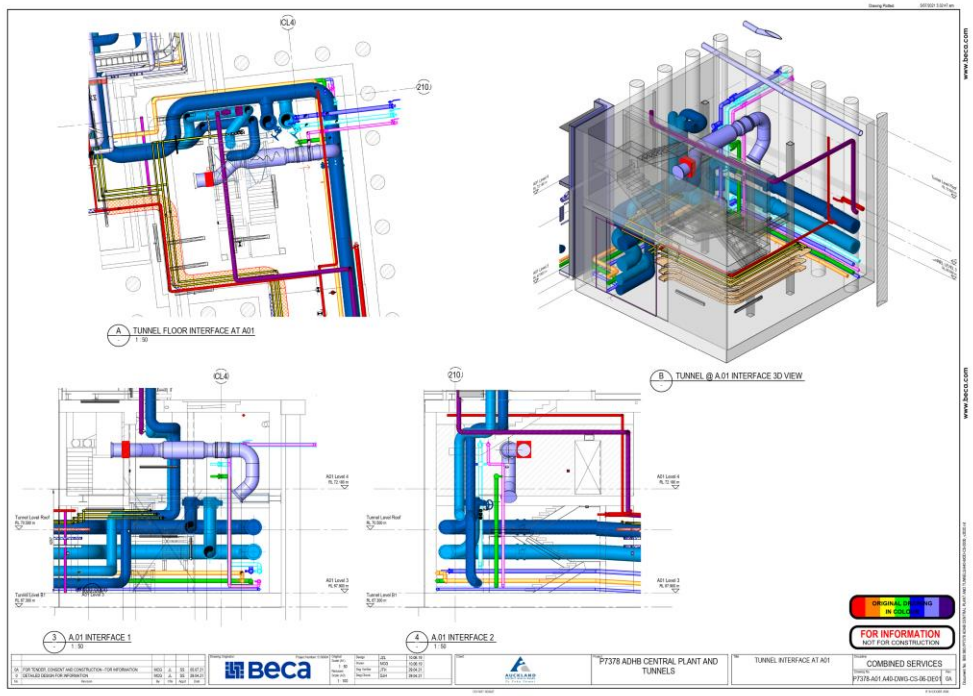
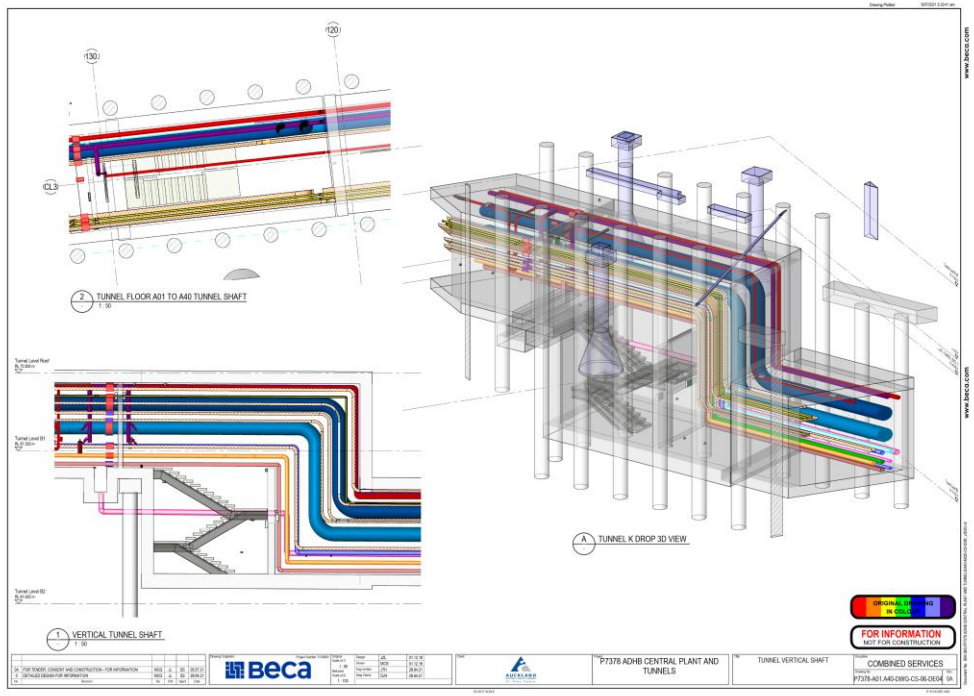
Service Tunnels

Examples of Complexity





Service Tunnels – Operations Phase

AUCKLAND DISTRICT HEALTH BOARD
Te Toka Tumai

Safe in Design

RISK REGISTER: 2.Ops-Maintenance (Tunnel)

Version: 5.0 Revised Aug 19 **Issued: Mar 21**

Project name / number: P7378 Central Plant and Tunnels

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TO1	PM/ design team	Tunnel infrastructure maintenance and replacement	Position of services resulting in maintenance access difficulty	2. Egress / Access	2	3	6		Position services reticulation for installation and maintenance accessibility, future flexibility and service addition allowance, zoning/grouping for each service trade to minimise cross overs. Sufficient corridor widths/working spaces for maintenance accessibility Provision of tunnel access hatches and gantry lifting beam above stairs for material transportation Tunnel gradients kept low. Genral power outlets provided from dual elec feeds. Ventilation system provides 2 modes incl a boost mode. Additonal opening can be used for additonal vent if required.		1	2	2		PM/ design team	11/03/2021	open
T02	PM/ design team	Inability to communicate through cellphones	Emergency communications	3. Communications	2	3	6		Provision of intercom system at each tunnel fire separation and emergency/panic buttons within tunnel Provision of manual call points. Incl CCTV in tunnel entrances. Wifi provide for in tunnel	Arrange for buddy system prior to tunnel entry. ADHB to provide radios	1	2	2		ADHB	11/03/2021	open
TO2	PM/ design team	Hazardous air quality in tunnel	Exposure/explosion risk	2. Fire / Explosion	2	4	8		Provision of ventilation system and gas detection system O2, and Co2 sensors with indicator display at each tunnel compartment entry relay to BMS. Use of portable gas detectors upon entry as validation Provision of automatic gas shut off valve to minimise build up/volume of gas upon detection of concentrations exceeding Worksafe figures. Provide option to run duty and standby fans together as a boost mode,	Specific JSA for high risk activities required	1	3	3		ADHB	11/03/2021	open
T03	PM/ design team	Pipe leaks	Explosion and slip risks, flood risk	2. Fire / Explosion	2	4	8		Pressure test piping during commissioning. Appropriate pipe support and restraint. Provision of drainage within tunnel with appropriate grading to minimise spread. Water/diesel separator collection at end of tunnel below A40 building. Consider locating natural gas outside of tunnel (underground) due to unpredictable fire/explosion risks associated with the natural gas. Nat Gas system was deleted. Position sumps prior to stairs. Use of non slip surfaces to floor and stairs Regular PPM/Inspection Separation of wet and dry services within tunnel Provison of incremental valve sets say each fire cell with drain pipefor mtce		1	3	3		PM/ design team	11/03/2021	open
T04	PM/ design team	Welding of pipes in the tunnel	Fire risk	2. Fire / Explosion	2	4	8		Minimise use of welded joints where possible. Appropriate hot work permit and protection on other services. Apply appropriate JSA and check tunnel environment prior to commencing work. Separation of medical gas pipes away from hydraulic pipes to minimise risk	Assessment required aorudn how air quality will be managed in event is required.	1	3	3		PM/ design team / ADHB	11/03/2021	open

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Next Steps

Working with the Contractor and key Subcontractors

We are currently working with a Preferred Tenderer to award the Contract for Central Plant and Tunnel, to ensure the Safety in Design initiatives are carried forward.

The Safety in Design register has been handed over to the Preferred Tenderer and will continue to be referenced, used and updated during the construction phase of the project. Managing the hazards of harm to all persons who will build, manage or use the new assets is an ongoing collaboration between all parties involved in the project.

Broadly construction and operational risks are well known and understood in the industry However, the biggest risk for this project will be the transition of reliance from the old infrastructure to the new, and the challenges posed on integrating dis-similar systems on an operational tertiary hospital.

A staged approach will be undertaken for integration and migration to minimise risk, that will jointly be planned between Auckland DHB and the Contractor to ensure continuity of service for clinicians and their patients.

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Wrapping it Up

Any Questions/Feedback?