22 – 26 June 2026

Mathematics-in-Industry New Zealand 2026

Auckland University of Technology

People

Co-Directors	Dr Hammed Olawale Fatoyinbo, AUT Dr Ryan Ip, AUT
Plenary speaker	Dr Luke Fullard, Team Leader Science, Data & Environmental Reporting, Horizons Regional Council

Welcome

The Mathematics-In-Industry New Zealand (MINZ) workshop is a unique opportunity for industry and the academic community to collaborate on creative solutions to real world challenges, adding value to our community and providing opportunities for research and partnership. This year, MINZ is hosted at Auckland University of Technology.

We are putting forward three challenges to our attendees from **Horizons Regional Council** and **Malaghan Institute of Medical Research & BioOra**. These challenges will enable our attendees to explore a variety of solutions that are focused on applied mathematics, statistics, and data science.

We also welcome **Dr Luke Fullard**, Science Team Leader for Data and Environmental Reporting at Horizons, as our plenary speaker. Before joining Horizons, Luke was a lecturer in applied mathematics at Massey University, and co-directed MINZ in 2017.

This year, MINZ opens a new chapter by being part of New Zealand Mathematics Society (NZMS). We acknowledge the support for this event from NZMS. We hope all of you will enjoy your time here!

Co-Directors,

Hammed and Ryan

Challenges

Challenge 1

Safe to Swim? Rapid Risk Forecasting for Horizons Regional Council Contact Recreation Sites

Challenge 2

Feeling the Heat: Predicting and Mitigating River Temperatures Under Climate Change

Challenge 3

Dual-Antigen CAR T-Cell Therapy: Selecting a manufacturing strategy that maximises tumour clearance under patient, tumour, and product variability

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Plenary speaker

Luke Fullard is the Science Team Leader for Data and Environmental Reporting at Horizons Regional Council.

Luke has been working in the Science Team at Horizons Regional Council for the last 5 years. He currently manages a variety of staff who specialize in geospatial data analysis, science communication, ecology and land science, air quality, and Mātauranga Māori. His own work covers data analysis, modelling, reporting, project management, and automation. Some interesting projects include using machine learning models for automated outlier detection, natural language processing, analysis of survey data, spectral methods for "gappy" time series, and modelling of water quality across the region.

Prior to his work in local government he worked as an applied mathematician and lecturer at Massey University, with his research spanning the fields of fluid mechanics, natural hazards modelling, and industrial process modelling. Luke was previously a Rutherford Foundation Postdoctoral Fellow and was the recipient of a Marsden Fast-Start Grant for his work modelling dense granular flows.

Luke has been actively involved with MISG and MINZ over the past decade as a participant, co-convenor, and co-Director of the 2017 NZ study group.

Luke is looking forward to sharing his experience of moving from academia to local government, and highlighting similarities and differences he has experienced between these two sectors.

Programme

Day 1 – Monday, 22 June 2026

08:30 – 09:15	Registration	WZ416
09:15 – 09:40	Welcome & Housekeeping	WZ416
09:40 – 10:30	Plenary speaker – Dr Luke Fullard	WZ416
10:30 – 11:00	Morning tea	WZ G/F
11:00 – 11:30	Industry presentation 1 – Horizons 1	WZ416
11:30 – 12:00	Industry presentation 2 – Malaghan & BioOra	WZ416
12:00 – 12:30	Industry presentation 3 – Horizons 2	WZ416
12:30 – 13:30	Lunch	WZ G/F
13:30 – 15:00	Project breakouts	WZ501, 502, 517
15:00 – 15:30	Afternoon tea	WZ G/F
15:30 – 17:00	Project breakouts	WZ501, 502, 517

Day 2 – Tuesday, 23 June 2026

09:00 – 10:30	Project breakouts	WZ501, 502, 517
10:30 – 11:00	Morning tea	WZ G/F
11:00 – 12:30	Project breakouts	WZ501, 502, 517
12:30 – 13:30	Lunch	WZ G/F
13:30 – 15:00	Project breakouts	WZ501, 502, 517
15:00 – 15:30	Afternoon tea	WZ G/F
15:30 – 17:00	Project breakouts	WZ501, 502, 517

Programme

Day 3 – Wednesday, 24 June 2026

09:00 – 09:30	Project update 1 – Horizons 1	WZ416
09:30 – 10:00	Project update 2 – Malaghan & BioOra	WZ416
10:00 – 10:30	Project update 3 – Horizons 2	WZ416
10:30 – 11:30	Morning tea	WZ G/F
10:45 – 12:30	Project breakouts	WZ501, 502, 517
12:30 – 13:30	Lunch	WZ G/F
13:30 – 15:00	Project breakouts	WZ501, 502, 517
15:00 – 15:30	Afternoon tea	WZ G/F
15:30 – 17:00	Project breakouts	WZ501, 502, 517
18:00 – 20:00	Networking dinner	WZ G/F

Day 4 – Thursday, 25 June 2026

09:00 – 10:30	Project breakouts	WZ501, 502, 517
10:30 – 11:00	Morning tea	WZ G/F
11:00 – 12:30	Project breakouts	WZ501, 502, 517
12:30 – 13:30	Lunch	WZ G/F
13:30 – 15:00	Project breakouts	WZ501, 502, 517
15:00 – 15:30	Afternoon tea	WZ G/F
15:30 – 17:00	Project breakouts	WZ501, 502, 517

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Programme

Day 5 – Friday, 26 June 2026

09:00 – 09:30	Project presentation 1 – Horizons 1	WZ416
09:30 – 10:00	Project presentation 2 – Malaghan & BioOra	WZ416
10:00 – 10:30	Project presentation 3 – Horizons 2	WZ416
10:30 – 10:40	Final remarks & Closing	WZ416
10:40 – 11:10	Morning tea	WZ G/F
	Farewell	

Challenge 1

Breakout room	WZ501
Industry representative	Ian Hurst & Luke Fullard
Moderator(s)	Dr Parul Tiwari (AUT)

Safe to Swim? Rapid Risk Forecasting for Horizons Regional Council Contact Recreation Sites

Utilising rainfall, flow, and site history to predict daily public health risks in-lieu of physical sampling

Background

Throughout New Zealand, regional councils monitor recreational water quality to assess public health risks from faecal contamination—indicated by *E. coli* in freshwater and enterococci in coastal environments. Traditionally, this monitoring relies on routine physical sampling followed by laboratory analysis. However, laboratory analysis inherently introduces a 24 to 48-hour delay before results are returned. Factoring in transportation and reporting protocols, a sample collected on Monday morning may not have its results communicated to the public until Wednesday or Thursday. Because water quality can change rapidly following heavy rain, this lag can result in the public being given out-of-date information that does not reflect current health risks. To bridge this gap, organisations are shifting toward dynamic "nowcasting" models that synthesise historical sampling data with real-time environmental variables to predict swimmability on a more frequent basis.

Note on Public Reporting: Physical sampling data and real-time predictions generated by these models are reported to the public via the Land, Air, Water Aotearoa (LAWA) website. The LAWA platform serves as the national "one source of truth" for recreational water quality communications, displaying real-time predictions alongside long-term site grades in its "Can I Swim Here?" section so that the public can make informed decisions before swimming.

Challenge Overview / Problem Specification

The core problem is to determine whether we can accurately predict the real-time risk to swimmers in lieu of physical sampling, using environmental drivers such as rainfall, turbidity, and river flow. A key component of this mathematical challenge is managing the asymmetric, uneven risk associated with the model's predictions:

- **False Positives:** If the model predicts it is unsafe to swim when the water is clean, it creates an opportunity cost and a loss of recreational amenity.
- **False Negatives:** If the model predicts the water is safe when it is contaminated, there is a severe public health risk. For instance, a recent evaluation of the Greater Wellington Regional Council (GWRC) model [2] highlighted that eliminating false negatives must be the primary focus to protect public health.

The study group will need to determine whether a single, generic model can be applied across all swim sites, or if localised models—accounting for complex hydrodynamics and individual catchment topographies—are required.

Key Factors and Variables

To build a robust predictive framework, the mathematical approach will need to consider several physical and environmental parameters. Current models in New Zealand commonly utilise:

- **Rainfall:** 24-hour and 48-hour observed rainfall.
- **Hydrological Dynamics:** River flow (discharge) rates.
- **Site History:** Long-term microbiological history, often expressed as a 5-year Swimmability grade.
- **Catchment Characteristics:** Upstream land use (e.g., urban vs. pastoral).
- **Turbidity Data:** discrete spot sampling and (less common) continuous data.

Data Available

The team will be provided with datasets to train and validate the predictive models, potentially including:

- Historical microbiological lab results (concentrations of *E. coli* and enterococci) spanning multiple years.
- Continuous hydrological data, including river flow and rainfall data.
- Upstream land-use characteristics.

Desired Outcomes

The goal is to develop a computational model (or suite of models) capable of outputting a reliable daily swimmability risk score for recreational sites, which can then be fed directly into public-facing platforms like LAWA. The ideal solution will outline a clear algorithm that successfully penalises false negatives to prioritise public health while remaining sensitive enough not to issue blanket "unsafe" warnings all summer.

Model Transparency and Interpretability: Regulators must be able to defend their decisions to the community, making model transparency critical. The study group should explicitly consider the trade-off between model complexity and usability. An opaque, "black-box" artificial neural network that achieves 99% accuracy may be less useful operationally than a slightly less accurate but highly interpretable, framework like a decision tree. We strongly prefer an interpretable model where the exact drivers of risk (e.g., "the algorithm flagged this site because of the 48-hour flow rate") can be easily audited by staff and clearly communicated to the public.

Challenge 2

Breakout room	WZ502
Industry representative	Luke Fullard
Moderator(s)	Dr Melody Whitehead (MU) and Dr Hammed Fatoyinbo (AUT)

Feeling the Heat: Predicting and Mitigating River Temperatures Under Climate Change

An open-ended mathematical modelling challenge to predict river thermal regimes under future climate scenarios and quantify the cooling effects of riparian shading and flow management.

Background

According to the Horizons Regional Council *Climate Action Strategy [2]*, New Zealand's climate has already warmed by approximately 0.09°C per decade since 1909. The same strategy notes that in the Manawatū-Whanganui region, average air temperatures are projected to increase by up to 3.1°C by 2090. Furthermore, the *Manawatū-Whanganui Regional Climate Change Risk Assessment* [5] highlights that the region will experience a dramatic increase in "hot days" (exceeding 25°C), with areas like Whanganui and the Taumarunui hill country projected to see 50 to 60 more hot days per year by the end of the century under high-emission scenarios.

Hydrological Shifts: These climatic shifts will heavily impact river hydrology. As detailed in the *Climate Action Strategy [2]*, summer flows in the Manawatū River are projected to decrease by up to 14% by 2090, while annual rainfall is projected to increase by 15-20% in the north and decrease in the southeast by 20%.

Impacts on Freshwater Species and Algae: The combination of warming waters and reduced summer flows presents a severe threat to freshwater ecosystems. Rising water temperatures threaten aquatic species, which are already highly vulnerable to shifting climate conditions and loss of habitat. For example, studies show that water temperatures between 23°C and 25°C cause lethal thermal stress and increased mortality in trout [1].

Furthermore, these conditions are understood to favour the proliferation of toxic benthic cyanobacteria. The report *Climate change and toxic freshwater cyanobacteria in Aotearoa New Zealand* [4] indicates that *Microcoleus autumnalis* mats dramatically increase when water

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temperatures exceed 14°C and when river flows drop, reducing the frequency of the "flushing flows" that naturally scour the algae from the riverbed. These cyanobacteria produce neurotoxins that pose lethal risks to animals and significant health hazards to animals and humans.

Challenge Overview / Problem Specification

This is a blue-skies project. We are not prescribing a specific methodology; instead, we are open to *any* mathematical, statistical, or computational approaches that the study group believes will be effective.

Your core challenge is to model and predict the thermal regimes of rivers under future climate change scenarios and determine how the effects of these temperature increases can be mitigated. You may choose to explore deterministic energy-budget models that balance solar radiation and convective heat transfer (as discussed, for example, in *The thermal regime of rivers: a review [1]*), stochastic models utilising long-term and short-term air/water relationships, regression models, or entirely novel machine-learning, or other approaches.

Specifically, we ask the study group to explore:

- How much will our natural waterways warm under future air temperature and low-flow projections?
- To what extent can mitigations reduce the risk of extreme thermal events and keep waters below critical biological failure states? We specifically want you to investigate the cooling effects of:
    - **Riparian shading:** Blocking solar radiation, which *The thermal regime of rivers: a review* identifies as a critical factor in river heating.
    - **Flow management:** Augmenting river discharge. For example, what is the impact of restricting water takes during summer droughts.

Key Factors and Variables

The models should consider a variety of environmental forcing factors and mitigation variables, which may include:

- Atmospheric and Meteorological Data
- Hydrological Dynamics
- Biological Thresholds
- Mitigation Levers

Data Available

The team will be provided with:

- River temperature, flow, and gauging data.
- Riparian vegetation and stream shading estimates.

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- Regional climate projections from the *Manawatū-Whanganui Regional Climate Change Risk Assessment*, including projected increases in "hot days" and potential evaporation deficits.
- Historical biological monitoring data regarding cyanobacterial coverage.

Desired Outcomes

Because this is a blue-skies initiative, we are looking for innovative modelling frameworks which will help inform us of potential future management options.

Supporting References

1. Caissie, D. (2006). *The thermal regime of rivers: a review*. Freshwater Biology, 51, 1389–1406.
2. Horizons Regional Council. (2023). *Climate Action Strategy*.
3. Horizons Regional Council. (2023). *Manawatū-Whanganui Climate Change Action Plan 2023*.
4. Puddick, J., Kelly, L. T., & Wood, S. A. (2022). *Climate change and toxic freshwater cyanobacteria in Aotearoa New Zealand*. Prepared for the New Zealand Ministry of Health. Cawthron Institute Report No. 3765.
5. Tonkin & Taylor Ltd. (2021). *Manawatū-Whanganui Regional Climate Change Risk Assessment*. Prepared for Horizons Regional Council.

Challenge 3

Breakout room	WZ517
Industry representative	Joshua Duley
Moderator(s)	Dr Steve Taylor (University of Auckland)

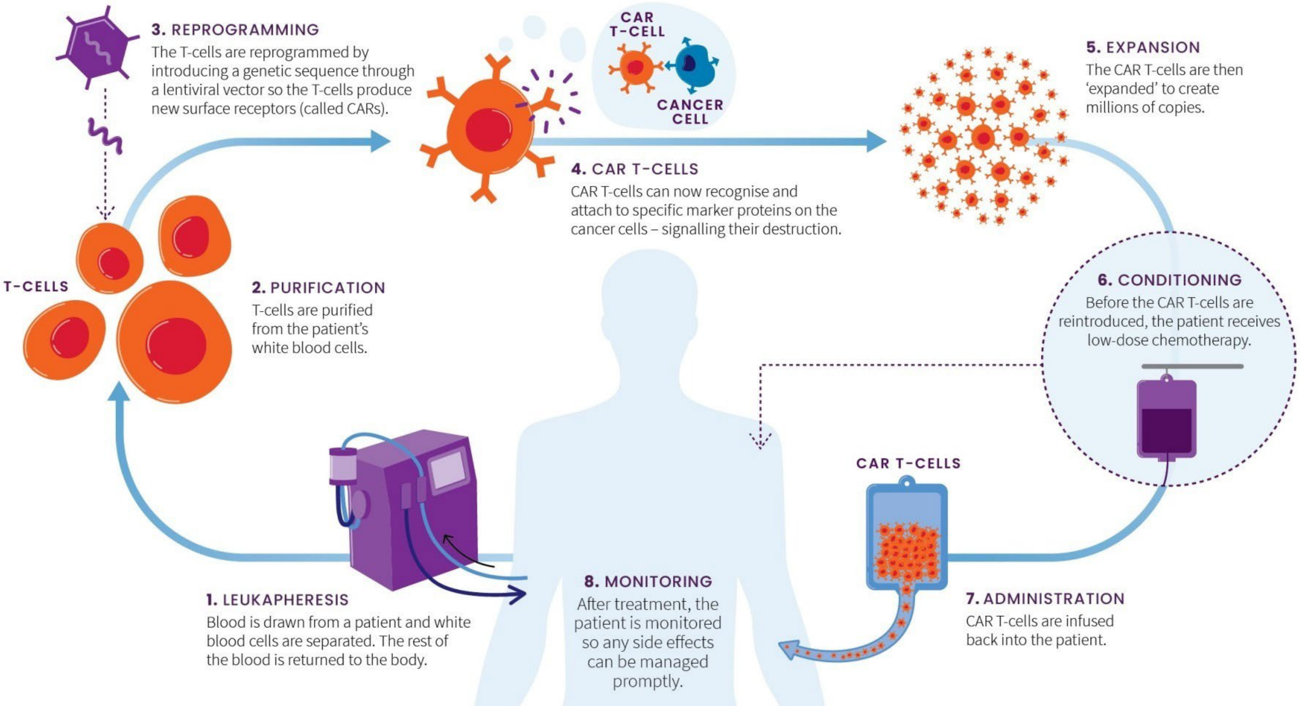
Dual-Antigen CAR T-Cell Therapy: Selecting a manufacturing strategy that maximises tumour clearance under patient, tumour, and product variability

Background

CAR T-cell therapy is modelled as two interacting cell populations. *Effector* cells are patient T cells modified ex vivo to express a chimeric antigen receptor (CAR), a surface protein that binds a designated target antigen. *Target* cells are tumour cells that express that antigen at varying levels. After infusion, contact between an effector and a target via CAR–antigen binding triggers killing of the target with some probability and may stimulate the effector to divide. The two populations evolve concurrently: effectors expand, accumulate exhaustion, and apoptose (die); targets deplete via successful kills. The population of CAR-T cells begins with heterogeneous characteristics, but as cells apoptose we see cell diversity diminish with characteristics inherited parent-to-daughter through division.

Approved single-antigen CAR T-cell products treat certain lymphomas, B-cell leukaemias, and myeloma (Majzner and Mackall 2019). The next generation of CAR T-cell products aims to broaden therapeutic reach by targeting multiple tumour antigens at once. Three manufacturing strategies for delivering dual coverage are described in the modelling and clinical literature (Bodnar et al. 2025; Li et al. 2026): two separate single-CAR products co-infused (2s), a single dual-CAR transgene expressed by every infused cell (dCAR), and a two-vector mixed product containing single-CAR and dual-CAR cells in tandem (2v). Each route is a different design decision that propagates through manufacturing complexity, expansion kinetics, and the in vivo behaviour of the infused population.

Comparing the three strategies experimentally would require expensive and time-consuming laboratory or clinical trials. Virtual-patient simulations allow comparisons across a distribution of patient, tumour, and product variability before manufacturing investment is committed. Determining which strategy is most effective will directly support the Malaghan CAR T-cell research programme's goals of improving the safety and effectiveness of CAR T-cell therapy.



CAR T-cell manufacture and treatment workflow, from leukapheresis through ex vivo reprogramming, expansion, and reinfusion (Malaghan Institute).

Objective

We aim to develop a stochastic agent-based model, embedded in a Monte Carlo virtual-patient framework, that allows the three dual-antigen manufacturing strategies to be compared on equal footing across a realistic distribution of patient, tumour, and product variability.

- Which manufacturing strategy maximises the probability of complete tumour clearance across realistic patient variability?
- How do antigen heterogeneity, infusion dose, and effector-pool composition interact to determine outcome?
- Is there a regime in which a mixed two-vector product (2v) outperforms both pure strategies, or is it strictly dominated?

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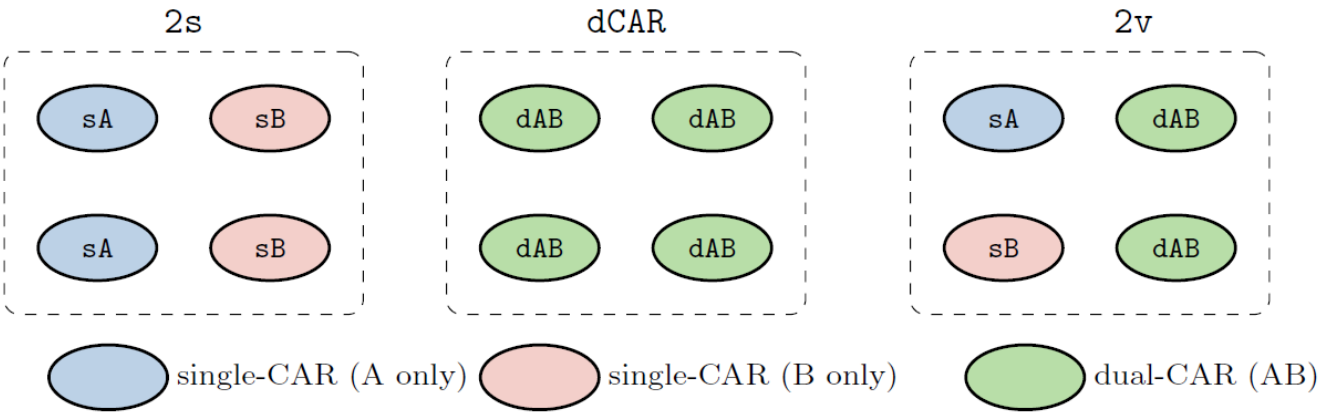

The three competing manufacturing strategies and the resulting effector cell compositions infused into a virtual patient. sA and sB denote single-CAR cells targeting antigen A or B respectively; dAB denotes a dual-CAR cell carrying both receptors.

Data

Calibration draws on published clinical and laboratory data:

- CAR-T expansion kinetics (fold-expansion, time-to-peak) from reported clinical studies.
- Antigen expression density distributions from tumour (flow-cytometry) data.
- Single-antigen efficacy data from approved-product trial reports.
- Tumour-burden distributions at therapy onset across reported trial cohorts.

References

Marek Bodnar, Monika J. Piotrowska, Mariusz Bodzioch, Juan Belmonte-Beitia, and Urszula Fory´s. Dual CAR-T cell therapy for glioblastoma: strategies to cure tumour diseases based on a mathematical model. *Nonlinear Dynamics*, 113(2):1637–1666, 2025. doi: 10.1007/s11071-024-10258-x.

Runpeng Li, Michael Barish, Margarita Gutova, Lisa A. Feldman, Christine E. Brown, Russell C. Rockne, and Heyrim Cho. Mathematical modeling of combinatorial antigen targeting with multiple CAR T-cell products for glioblastoma treatment. *npj Systems Biology and Applications*, 12(1):19, 2026. doi:10.1038/s41540-025-00642-7.

Robbie G. Majzner and Crystal L. Mackall. Clinical lessons learned from the first leg of the CAR T cell journey. *Nature Medicine*, 25(9):1341–1355, 2019. doi: 10.1038/s41591-019-0564-6.

Campus

MINZ is being hosted by the School of Engineering, Computer and Mathematical Sciences at Auckland University of Technology. All events will be held in WZ Building, St Paul Street, Auckland CBD. Within walking distance, you will find lots of cafes, restaurants, and shops.

SCHOOLS

Art & Design – Level 3, WE building
Business – Level 1, WF building
Communication Studies – Level 12, WG building
Engineering, Computer & Mathematical Sciences – Level 3, WZ building
Future Environments – Level 11, WG building
Hospitality & Tourism Reception – Level 3, WH building
Law – Level 3, WY building
Science – Level 1, WS building
Social Sciences & Humanities Reception – Level 3, WB building
Te Ara Poutama Reception– Level 3, WB building

STUDENT HUB

Level 2, WA building

SERVICES AND FACILITIES

AUT International – Level 16, WO building
AUT Security – Corner St Paul & Wakefield St, WO building
AUT Shop – WH102, WH building
AUT Student Association (AUTSA) – Level 2, WC building
Library – Level 4, WA building
PinkLime (print services) – Level 3, WA building
Student Accommodation & Recreation Centre – WQ building
Mōwai Student Health & Counselling – Level 4, WQ building
Rainbow Student Support – Level 4, WQ building
Tech Central – Level 4, WA building

Student Hub
Student lounge & study space
Café
Library
Gym
Conference facility
City Campus-South Campus shuttle bus stop
Baby feeding rooms
Mobility parks
Defibrillator

WA4 Hikuwai Plaza, outside library
WF01 Lift lobby
WG1 Help desk in the atrium
WH209 Piko restaurant
WO2 Security reception
WS01 Lift lobby
WY1 Mayoral Drive – lift lobby
WQ3 Reception area
WQ4 Mōwai Student Health & Counselling