

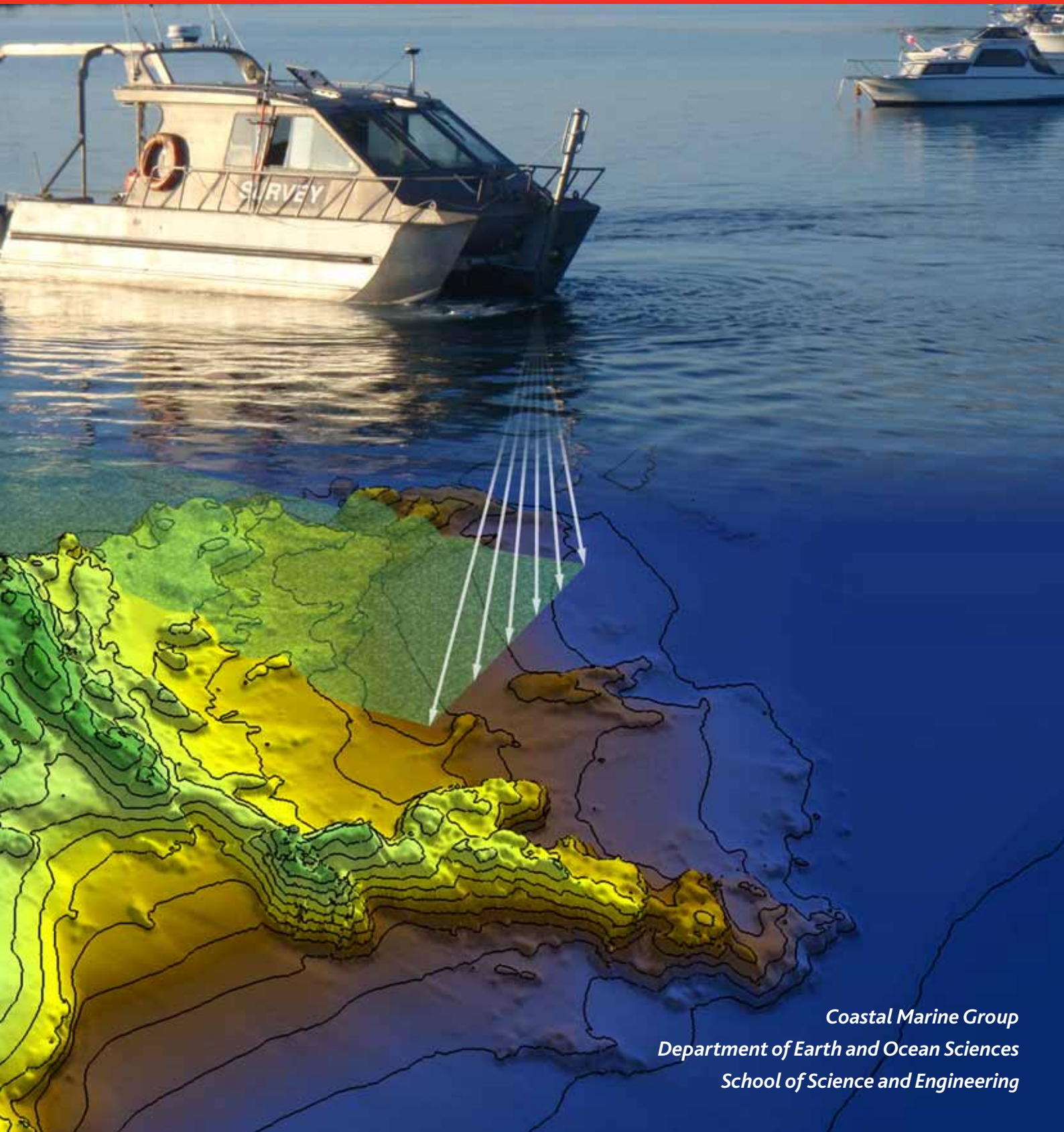


THE UNIVERSITY OF  
**WAIKATO**  
*Te Whare Wānanga o Waikato*

# *Shallow Water Mapping*

*of Coastal Environments, Inland Lakes and Waterways*

*Measuring and Monitoring New Zealand's Marine and Freshwater Resources*



*Coastal Marine Group  
Department of Earth and Ocean Sciences  
School of Science and Engineering*

## MANAGING A VALUABLE RESOURCE

---

Marine and freshwater resources and ecosystems are now recognised as ranking among the world's most valuable assets, and their management is subject to intense debate. New Zealand has jurisdiction over a maritime area that is 24 times the size of our land mass, yet relatively little is understood about this area's resources and carrying capacity.

In New Zealand these assets are largely managed through the Resource Management Act 1991, together with legislation regulating our fisheries and aquaculture industries, and other ancillary regulations and policies.

**The integrated management of marine and other water resources, and the growing complexity of the regulatory environment, requires a sophisticated and systematic approach to data collection and monitoring of these resources.**

## SHALLOW WATER MAPPING

---

**The University of Waikato's Coastal Marine Group is a specialist niche operator in shallow water mapping and surveying, meeting the needs of researchers, managers and developers of New Zealand's marine and water resources.**

Specialist equipment mounted on survey vessels collect information that can measure and map the shape of the seabed, lake or waterway, help create hydrodynamic flow models, and provide information about the geological characteristics (rock, sand, sediment) of the waterway or sea floor. This information can be used to monitor natural changes in the environment from tides, currents and sediment movement, as well as the impact of man-made coastal structures, modified water flows and discharges, dredging and dredge spoil disposal.

## WHO NEEDS IT?

---

### Planners, regulators and environmental managers

Regional Councils use mapping information for the development of regional coastal plans, the identification of aquaculture management areas, the management of environmental hazards (from coastal erosion to tsunamis), and the administration of the use of our coastal and inland water resources through consent and monitoring processes.

Central government agencies with responsibilities for the coastal and marine environment include the Department of Conservation, Ministry for the Environment, Ministry of Fisheries, and Land Information New Zealand.

### Developers, resource users and researchers

Shallow water mapping is an important tool for District Councils, ports authorities, power companies, and developers seeking, or complying with resource consents for underwater construction (e.g. dams, bridges, marinas, and coastal protection), aquaculture, river flow control, discharge and extraction activities. It also underpins independent research on shoreline management, lake and waterway health, and maritime resources.

*“ Water resources and aquatic ecosystems are essential to New Zealand's economy. They are also a significant part of our natural heritage, our recreational activities, and of particular practical and spiritual value for Māori ”, Ministry for the Environment, NZ, [www.mfe.govt.nz/issues/water](http://www.mfe.govt.nz/issues/water).*



## THE COASTAL MARINE GROUP

### A Unique Service that Meets Your Budget

The Coastal Marine Group (CMG) has more than 30 years' experience in state-of-the-art sampling, measurement and monitoring of shallow water environments. Our strength lies in applying coastal research to real-world issues – providing a scientific basis for resource management from environmental policy to engineering works.

Our equipment is customised for use in small survey vessels ranging in length from 19m down to a 3m inflatable. This supports a range of mapping requirements in offshore and inland locations, particularly in coastal and shallow waters.

Our multidisciplinary team can tailor its services to meet research and commercial needs. Small survey vessels, and the flexibility to reschedule work when weather and tide permit, allows us to offer a relatively low-cost mapping service, provided urgency is not a requirement.

### Service Specifications

The CMG specialises in bathymetry (underwater topography), wave and current flows, sediment movement, and marine geology for environmental and engineering research and management purposes. We do not undertake hydrographic surveys for navigational safety.

Data is validated and formatted for integration with Geographic Information System (GIS) databases that, for example, councils commonly use for planning purposes. Bathymetric maps (undersea topography) and 3D animations can be produced to visualise the data collected.

The CMG's customised mapping equipment includes:

- side scan sonar – to provide a two-dimensional image of the sea/lake floor with different reflectivities showing different types of bed surfaces
- single beam echo sounder (SBES) – to provide accurate single depth measurements with a hydrographic quality dual frequency system that can penetrate superficial sediment layers.
- multi-beam echo sounder (MBES) to provide a wide swath of multiple depth measurements for three-dimensional bathymetric shape imaging of the waterbed
- real-time kinematic global positioning system (RTK GPS) – to provide horizontal and vertical positioning of soundings including water level measurements and heave compensation for the SBES system

A wide range of other equipment can also be utilised including Acoustic Doppler Current Profilers (to measure currents at all depths of the water column), other wave and current meters, grab samplers (for sampling sea, river or lake bed), and drop camera (for remote video monitoring).

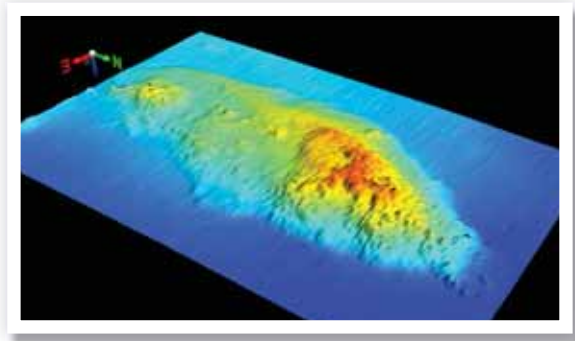


## CASE STUDIES

### Bay of Plenty

Offshore reefs are environmental assets supporting biodiversity and fish stocks in the Bay of Plenty. The management of these resources is now supported by survey data showing where these reefs are and what they look like.

Further research using pioneering methodologies developed by CMG researchers has also enabled Environment Bay of Plenty to identify sustainable coastal marine locations for Aquaculture Management Areas, which will allow aquaculture growth without further pressure on coastal inlets.



### Whitianga

Whitianga is a popular, coastal marine area with multiple users and a fast-changing environment requiring considerable management. A marina and a canal-based subdivision are changing the tidal and sedimentation patterns, surrounding forestry developments are also affecting sedimentation of the harbour, and dredging operations require monitoring. As is common in many coastal areas, beach erosion is also an issue.

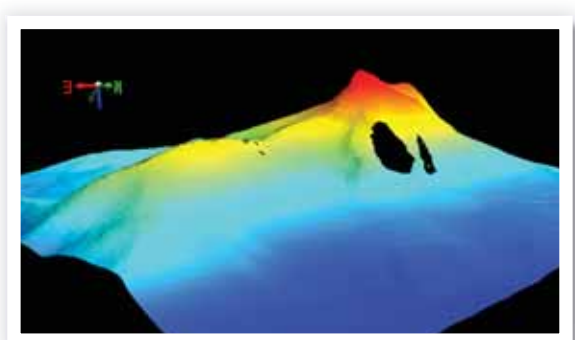
Using a combination of survey methods, the CMG charted the area for Environment Waikato, measured sedimentation patterns in the harbour and ebb-tidal delta, modelled the currents and water levels, revealing the effects of wind and tide, undertook tsunami modelling, and measured the impacts of the marina and waterway developments.



*Photo courtesy of Focus Photography, Whitianga*

### Rotorua Lakes District

Surveys of Lakes Rotorua and Rotoiti have been undertaken to support a major \$10 million lake restoration programme now being led by the University of Waikato. Lake Tarawera has been surveyed to develop understanding of the volcanic history of the area.



## Tauranga – Mt Maunganui

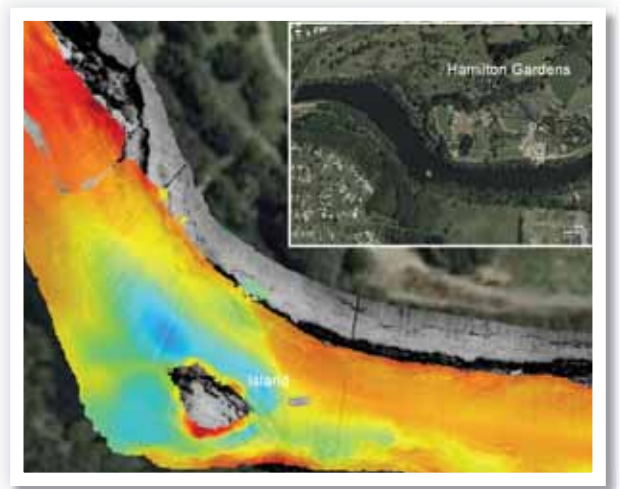
Tauranga is home to one of New Zealand's busiest ports and most popular beach resorts. An innovative dredging operation re-uses sand removed from the shipping channels to replenish Mt Maunganui Beach by dumping it where tide and current can carry it on to the beach. The CMG monitors the dredging operation through hydrographic surveys, bathymetry and computer modelling of tides, currents and sediment transport patterns in the shipping channels, the tidal inlet and off the beach. An artificial surfing reef built at nearby Omanu Beach is also the subject of ongoing research to determine its impact on coastal protection, habitat enhancement and ocean recreation.



*Photo courtesy of Port of Tauranga*

## Waikato River

A survey of the Waikato River has provided an accurate map of the channel and riverbed formations from Karapiro to Ngaruawahia. The survey, undertaken for a thesis, was funded by Mighty River Power to monitor the effects of its operation downstream of the last power station in the Waikato hydro-electric system at Karapiro, and to investigate sediment flow and the relationship between river channel characteristics and riverbank stability. The 50km stretch of the river surveyed passes through New Zealand's fourth largest city, Hamilton, where surrounding rural riverbank land is becoming more closely subdivided into life-style blocks – giving rise to increased public awareness of bank stability and questions about the potential effect of relatively rapid changes in river flow consequent upon demand for electricity.



## Raglan Surfing Breaks

The small west coast settlement of Raglan is world-renowned for producing consistent high quality surf conditions and attracts surfers from around the world to ride one of the longest left-hand breaks in the Southern Hemisphere. Surveys of the Raglan surfing breaks provide a scientific basis for the conservation of world-class coastal recreation areas.



*Photo courtesy of Raglan Chronicle*

## THE SURVEY PROCESS

### Survey Planning, Quoting, Contracting

- » No charge for work required to reach contractual agreement



### Control Surveying and Tidal Corrections

- » Research existing survey information (e.g. LINZ)
- » Initial site reconnaissance
- » Establish new survey control marks
- » Identify tidal correction method required (e.g. incline plane model) to calibrate RTK GPS measurements



### Optional Side Scan Reconnaissance

- » Rapid imaging of sea/lake bed characteristics to
  - identify key areas of interest
  - prioritise echo sounding survey time



### Echo sounder mobilisation and calibration

- » Measurements validated against existing information
- » Time varies from <1 hour for SBES, 2-3 hours for MBES, and 1-2 days to mobilise MBES on a new survey vessel



### SBES and MBES collection

- » SBES surveys navigate predefined run lines spaced from 5m-200m
- » MBES measures swaths about 3x water depth requiring a survey process akin to "mowing the lawn" using onboard computerised mapping, and periodic collection of SBES data to validate depth measurements. It provides up to 100% seabed coverage depending on survey budget and purpose.



### Data processing and validation

- » Side scan and MBES data display gives quality assurance at collection
- » Side scan data is later processed to create a 'geotif' of the seabed
- » MBES data is filtered to remove bad soundings and generalised into 'cells' from 0.25m<sup>2</sup> -5m<sup>2</sup> in size
- » All data, including SBES data, is validated using commercial software and custom GIS routines to compare existing and new data and to develop accuracy statistics for the survey



### GIS database integration

- » Digital datasets are the main data product from a survey
- » Collected datasets are converted into GIS database formats including ArcGIS shapefiles, and file-based geodatabase feature classes, rasters and terrains.
- » Map production (cartography)
- » Maps can be made to show the survey data collected
- » 3D animations and visualisation of survey data are options

## TECHNICAL SPECIFICATIONS

### Single Beam Echo Sounding (SBES)

- » The SBES system measures high frequency (200 KHz) and low frequency (33 KHz) single echo soundings directly below a transducer mounted to the survey vessel, and a GPS for horizontal and vertical (optional) positioning.
- » Individual high and low frequency depth measurements are recorded digitally. The echo sounding trace through the water column and within superficial sedimentary layers can be recorded digitally and onto paper.
- » Heave compensation can be provided through RTK GPS measurements
- » Single beam measurement can be made in depths as shallow as 1m.

### Multi-beam Echo Sounding (MBES)

- » The MBES system operates by transmitting a series of sound beams in a 120°-wide fan perpendicular to the vessel, and then processing the returned sonar data to determine a swath of depths representing the bottom topography. (Fig 1 from multibeam brochure)
- » MBES systems were first developed by the US military in about 1960 for use in submarines for surveying continental margins and abyssal depths and were introduced to the public sector in the 1970s. They depend on a very stable platform/vessel or a highly sophisticated position and attitude sensor (heave compensator and heading device). In the 1990s GPS (kinematic) technology improved to a level where multi-beam sonar could be operated successfully in shallow water from small vessels.
- » The MBES system is a much more complicated array of hardware and software than the SBES system. At the core of the system is a Simrad EM3000 transducer and processing unit. This unit processes input from the GPS, transducer and motion sensor, which is then transmitted via a network link to a Windows based Triton Imaging Inc. processing computer. The Triton Imaging Inc. processing computer displays real-time waterfalls of 2D and 3D depths, backscatter, and colour binning of sounding. The Triton Imaging Inc. suite achieves this using a combination of ISIS, BathyPro Realtime and DelphMap software packages.
- » The EM 3000 is a portable system with 127 beams fanning 120° – giving a swath width about 3 times the water depth and providing up to 100% seafloor coverage in the survey area. Features on the seafloor not discovered or missed in previous single beam surveys will become visible. The EM 3000 system achieves ocean depth of around 150 m and about 180 - 200 m in cold freshwater. With the EM 3000, backscatter data can also be logged. This acoustic backscatter data provides imagery similar to a side scan sonar system.

### Incline Plane Modelling

- » Incline Plane Modelling is a calibration method to correct for the difference between the WGS84 ellipsoidal height (as measured by GPS) and geoidal elevation. The WGS84 ellipsoid is a flattened sphere approximating the earth's surface, and the geoid is a surface that generally coincides with the mean sea level (MSL) of the ocean, which is of most interest for environmental applications. RTK GPS technology provides geometric (ellipsoid) height measurements, but most users expect orthometric (geoid) height measurements which – in simple terms - are accurate elevation readings related to MSL. The difference between the two may vary by up to 40 metres depending on location.
- » When RTK GPS is used for measuring water-level corrections during hydrographic survey, a calibrated incline plane enables real-time conversion of WGS84 heights to orthometric heights such as MSL.
- » An incline plane model is created mathematically by accessing or establishing survey marks with both WGS84 and orthometric levels in the survey region, and using these marks to fit an incline plane between the two surfaces (ellipsoid and geoid), providing a calibrated relationship between them across the whole survey region.
- » Trimble Geomatics Office and HYDROpro software are used to create and apply the model.

### Survey Vessels

- » There are five survey vessels available for use in different coastal environments.
- » Three are owned by the Coastal Marine Group:
  - » 3.9m pontoon boat "Waikohe", 25 Hp outboard, light inflatable – supports SBES only
  - » 6m pontoon boat "Taitimu", 135 Hp outboard, multi task craft – supports all mapping techniques
  - » 9m catamaran "Tai Rangahau", twin 150 Hp outboards, purpose built survey and diving craft – supports all mapping techniques
- » Two are owned by Western Work Boats Ltd, Tauranga, and hired for deeper water mapping purposes:
  - » 15.8m aluminium work boat "Macy Gray" – supports all mapping techniques
  - » 19.2m aluminium work boat "Star Keys" – supports all mapping techniques



THE UNIVERSITY OF  
**WAIKATO**  
*Te Whare Wānanga o Waikato*

## COASTAL MARINE GROUP

### Terry Healy

Research Professor of Coastal Environmental Science

phone/fax: +64 7 858 5200

mobile: +64 21 612 600

e-mail: [trh@waikato.ac.nz](mailto:trh@waikato.ac.nz)

### Dirk Immenga

Senior Technical and Diving Officer

phone: +64 7 858 5235

fax: +64 7 856 0115

mobile: +64 274 953 075

e-mail: [dirk@waikato.ac.nz](mailto:dirk@waikato.ac.nz)

Website: [http://earth.waikato.ac.nz/coastal\\_marine](http://earth.waikato.ac.nz/coastal_marine)

The University of Waikato  
Private Bag 3105  
Hamilton 3240  
New Zealand

Toll Free: **0800 WAIKATO**  
0800 924 528

Website: [www.waikato.ac.nz](http://www.waikato.ac.nz)