GNS SCIENCE

2020 ANNUAL REPORT

PART 1 – HIGHLIGHTS

Our science delivers tangible benefits to help Aotearoa New Zealand move towards a cleaner, safer, more prosperous future.

Cover photo: Braided channels in the Waimakariri River, Canterbury
Inside front cover: Tongaporutu Beach, northern Taranaki coast

OUR ACHIEVEMENTS

OUR SCIENCE

OUR ORGANISATION

Presented to the House of Representatives pursuant to the Crown Research Institutes Act 1992.

Our Annual Report is presented in two parts – Highlights (Part 1) and Reports and Financial Statements (Part 2). Together, these documents fulfil our annual reporting responsibilities under the Crown Research Institutes Act 1992 for the year ended 30 June 2020.

The Reports and Financial Statements (Part 2) includes performance indicators, the report of the directors, financial statements, and independent auditor's report.

Our Annual Report is also available in digital format at www.gns.cri.nz

Published by:
GNS Science, 1 Fairway Drive, Lower Hutt 5010, PO Box 30368, Lower Hutt 5040, New Zealand

www.gns.cri.nz

FROM THE CHAIR AND CHIEF EXECUTIVE

When Whakaari/White Island erupted at 2.11pm on 9 December 2019, it was the first of two major events which impacted and disrupted the work of GNS Science this year. The second was the COVID-19 pandemic. Both tragically took a human toll in Aotearoa New Zealand with people injured and lives lost, and both forced us to look at ourselves, as an organisation and as a country.

The Whakaari eruption called on the skills of our trained staff to respond to an evolving situation, providing up to the minute analysis of an erupting volcano. We are very proud of how our people stepped up, responding to an extraordinary level of media and public interest, while doing their core job of keeping decision-makers fully and accurately informed about the status of the active volcano.

Aside from the immediate operational response, the Whakaari event has challenged us to think about how we can always do our best for Aotearoa New Zealand. It is a call to action for everyone involved to ensure we can communicate complex scientific material clearly and effectively in a crisis. As the WorkSafe investigations into the event continue, we are looking ahead to what this type of situation means for us and the work we do for Aotearoa New Zealand, and the role we play in keeping our country safe.

COVID-19 response

During the COVID-19 pandemic lockdown, a combination of expertise, technology and dedication meant our systems and scientists continued to monitor and analyse the four geological perils – earthquake, volcano, tsunami and landslide. As essential services, the National Geohazards Monitoring Centre *Te Puna Mōrearea i te Rū* and GeoNet remained operational, with our staff practising social distancing and other new health protocols.

During lockdown, we contributed to our nation's response by helping the Ministry of Health set up the nationwide emergency mobile alerts system.

We were heartened by how our staff across all sites responded positively going into lockdown, during the period of isolation, and subsequently returning to a relatively normal way of working. During lockdown, we contributed to our nation's response by helping the Ministry of Health set up the nationwide emergency mobile alerts system. We also provided advice to the Prime Minister's Chief Science Advisor and the Science Advisor to the Ministry of Health on the COVID-19 alert levels in preparation for de-escalation.

COVID-19 has had a significant impact on our business. We have faced major constraints in our ability to deliver on and secure new revenue from international contracts. Delivery of science in Aotearoa New Zealand has also been affected by COVID-19. The funding boost we received from the Government was very much appreciated and offset much of the loss of commercial revenue.

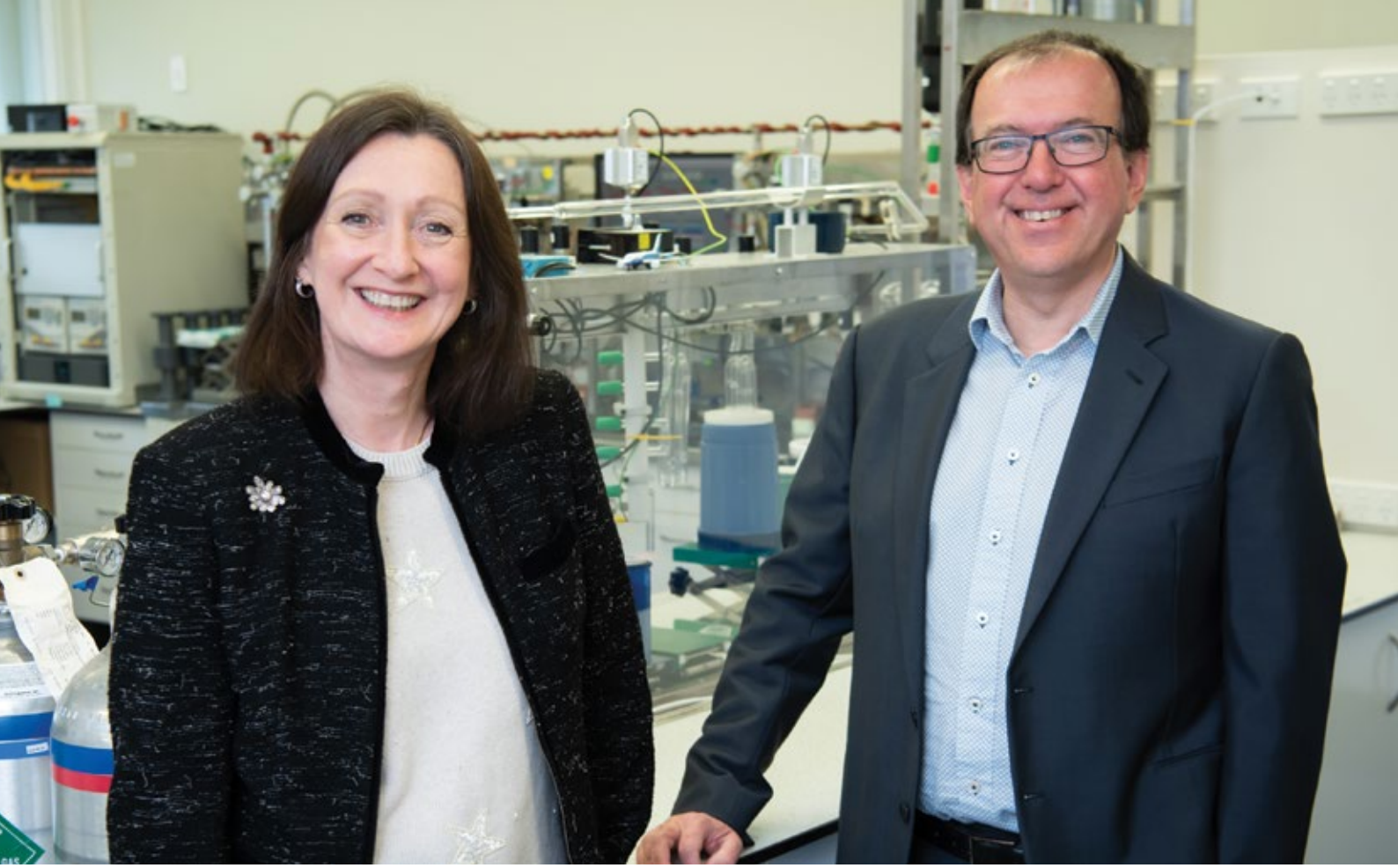
Investing in the business for the future

Despite the impact of COVID-19 we are investing in the business for the future, including in the implementation of our People and Culture Strategy. This will ensure we have the capabilities we need to meet the needs of the future and invest in growing leadership skills at all levels of the organisation.

We are also working to understand the investment required in our property and infrastructure, beginning with a comprehensive review to inform a new property development strategy. This strategy will be a framework for coordinated planning across our portfolio of facilities to integrate maintenance, improvement, construction and disposal of buildings and infrastructure. It will be set within the context of the people, places, processes and technologies required to create a built environment that underpins the delivery of our science. We are also keeping close links with other Crown entities looking to invest in property and will work with them where possible.

Regular reviewing of our work

It's important that our work is regularly and independently scrutinised to ensure it continues to focus on excellence and is tuned into national and international trends and opportunities. Our Strategic Scientific and User Advisory Panel (SSUAP) consists of international and domestic experts who provide a review of our research work and report directly to the Board.



This year we asked SSUAP to review our work in developing the direction of our new Science Themes – Natural Hazards and Risk, Environment and Climate, Energy Futures, and Land and Marine Geoscience. We have made strong progress with the implementation of the themes, following last year's review. This was an opportunity to get an independent perspective on the work to date.

It's important that our work is regularly and independently scrutinised to ensure it continues to focus on excellence and is tuned into national and international trends and opportunities.

We received some very positive feedback from SSUAP and some valuable recommendations which we are now acting on. These include building and implementing a Science Roadmap, developing and communicating our value proposition, and better integration of the enabling programmes of social science and data science into our research work. This strategic work is being led by our Executive Leadership Team, reporting to the Board, with input from across the organisation.

CRI Review

We welcomed the independent Te Pae Kahurangi review of all Crown Research Institutes (CRIs) this year. Overall, the review concluded that CRIs play a vital role in the science system, providing research that can be applied in support of evolving national priorities. It also provides a useful analysis of some of the issues CRIs face collectively.

The review recognised a range of issues in the science system, in particular the current science funding mechanisms. These do not provide the certainty and stability that CRIs require to deliver their strategic goals, they force often inefficient competition amongst research institutions, and are insufficient to support sustainable financial outcomes and investment in critical infrastructure.

The review's recommendations aim to build on our collective strengths and address some of the challenges all CRIs face. Our view is that an evidence-based approach should be taken to systematically test and refine any potential future options. The Chairs and Chief Executives of all the CRIs will continue to work together to move the discussion forward and help improve the system.

Financial result

GNS Science recorded a net profit after tax of $0.4 million for the year to 30 June 2020, very similar to last year, and $0.4 million below our budget. Total revenue was $95.4 million, compared to $95.3 million in 2019, and the 2020 budget of $103.6 million.

The financial impact of COVID-19 on GNS Science was significant, causing a negative impact on revenue in 2020, mostly from commercial projects. Despite these challenges, contestable research work was slightly ahead of last year ($0.4 million). Subcontract work was $1.2 million higher than 2019, reflecting our ongoing collaboration with other CRIs, universities and government agencies.

The COVID-19 lockdown and related restrictions resulted in reduced expenditure, particularly through delays in project costs, delays in international appointments, and reduced travel, partially offsetting our reduced income. Our operating expenditure was $90.5 million in 2020, $1.1 million ahead of 2019, and $6.6 million below our budget.

The WorkSafe and Coronial investigations and high level of public interest following the Whakaari/White Island tragedy have caused a major impact on resources and finances.

To date, nearly $0.5 million has been spent on post-eruption response and investigations, in addition to more than 3000 hours of time committed by science and non-science staff. This is in addition to the response to the eruption itself.

The Government's special COVID-19 related grant of $4.2 million at the end of the year stabilised the final unaudited result at near breakeven. The outlook for the year ahead is challenging given the ongoing pandemic and resulting economic pressures, however GNS Science continues to maintain a positive financial position to support our future direction.

Māori engagement

In our work as the Earth science Crown Research Institute, GNS Science needs enduring and sustainable relationships with tangata whenua – the people of the land. Steadily, Vision Mātauranga is becoming embedded in our work. Our Māori engagement strategy developed last year has become the norm for how we work with iwi/Māori when developing our research programmes. Our people are increasingly seeking to understand the Māori context and involve iwi/Māori early so they can fully participate and contribute. We already have many good working relationships, and we want to build many more to unlock the science and innovation potential of Māori knowledge to benefit all New Zealanders.

GNS Science is keen to increase Māori participation in science. We are seeking to nurture talent from Aotearoa New Zealand, and provide students with a chance to get experience which will help them build careers in science.

GNS Science is keen to increase Māori participation in science. We are seeking to nurture talent from Aotearoa New Zealand, and provide students with a chance to get experience which will help them build careers in science. Over the summer we had six students of Māori descent working with our scientists as part of our new Ahunuku Māori scholarship programme and Māori internship programme. We are looking to expand the programme over future summers.

Prestigious award for our scientists

We were delighted that our researchers were part of the team which won the Prime Minister's 2019 Science Prize. The work of the Melting Ice and Rising Seas team is a ground-breaking collaboration between GNS Science, Victoria University of Wellington and NIWA. It is tackling the link between climate change, Antarctic ice melt and sea level rise.

The group will use $400,000 of the prize to fund scholarships in perpetuity for PhD students in Antarctic and climate research – creating a legacy for emerging researchers in this crucially important field.

The Prime Minister's Science Prize encapsulates everything we stand for at GNS Science – world-class research in collaborative partnerships for the benefit of Aotearoa New Zealand. It is gratifying that climate change science was chosen to receive the award, and for GNS Science to be part of a team working on such a critical issue. Their research is a wonderful example of the great work being done by our scientists across a range of really important areas for Aotearoa New Zealand.

Looking ahead

We are very proud of the high-quality research work our scientists have produced this year, coping not only with internal change through the bedding-in of our new Science Themes, but also the disruption to normal work when COVID-19 struck.

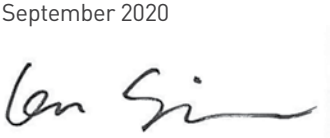
Every day our scientists are working on projects which underpin a cleaner, safer, more prosperous Aotearoa New Zealand.

We monitor and research natural hazards, keeping New Zealanders safe – while safeguarding environmental resources like groundwater, helping communities manage and adapt to climate change, and working on projects to address our energy needs now and into the future. The value of this research in meeting the needs of Aotearoa New Zealand is apparent in the projects featured in this Annual Report.

Looking ahead, science and innovation across the whole research sector will play a critical role in supporting the country's recovery from the global economic crisis resulting from COVID-19. Now, more than ever, is the time to be innovative and invest in future-facing, next-generation industries, and a productive, sustainable and resilient economy.

We believe science is key to delivering these. GNS Science is well-placed to help Aotearoa New Zealand unlock new value and build the country's economic resilience in these turbulent times.

Dr Nicola Crauford
Chair
September 2020



Ian Simpson
Chief Executive
September 2020

Left: The Stable Isotope Laboratory at GNS Science's National Isotope Centre, Lower Hutt.
Right: Scientists collect a laser scan of a landslide in the Southern Alps.

HONOURS AND AWARDS

GNS Science staff make extraordinary contributions to Aotearoa New Zealand. During the year, many of our staff were recognised for their outstanding work.

Prime Minister's Science Prize

GNS Science researchers are part of the **Melting Ice and Rising Seas** team that won the 2019 Prime Minister's Science Prize for their work tackling the link between climate change, Antarctic ice melt and sea level rise. The group will invest $400,000 of its prize to fund scholarships in perpetuity for PhD students in Antarctic and climate research. Read the full story on page 35.

2019 Science New Zealand National Awards

Supreme Winner

A multi-year GNS Science-led programme called **It's Our Fault** was named winner of the Supreme Award at the 2019 Science New Zealand National Awards at Parliament. These annual awards for the seven Crown Research Institutes recognise outstanding achievements in science that produce benefits for Aotearoa New Zealand. Each CRI has an award for Early Career Researcher, Lifetime Achievement, and Team. For the first time, last year's Awards featured a supreme winner, and **It's Our Fault** claimed that award.

It's Our Fault has been running since 2006. Many researchers from GNS Science have contributed to the programme as well as skilled earth scientists, planners, and engineers from other Crown Research Institutes and New Zealand universities. Its results are used in decision-making and policy-making to support the Wellington region's earthquake resilience.

Impact examples include increased resilience of Wellington's water network, tsunami blue lines in coastal suburbs, modelling post-earthquake fire spread, and pioneering the development and use of site class maps to inform the Building Code. While **It's Our Fault** has a focus on the Wellington region, its outputs have relevance to the whole of Aotearoa New Zealand.

The project has been acknowledged as a great example of GNS Science building on its 150-year history of research excellence – while embracing new, collaborative ways of working, and forming deep and lasting partnerships with project and community stakeholders.

Long-term funders are the Earthquake Commission (EQC), Wellington City Council, Wellington Region Emergency Management Office, MBIE's Strategic Science Investment Fund, and the Accident Compensation Corporation.

Pictured above: Russ Van Dissen, Caroline Holden, and Delia Tamsen of the *It's Our Fault* team.

GNS Science Early Career Researcher Award

Hazard and risk management researcher **Sally Potter** received the GNS Science Early Career Researcher Award. Sally conducts internationally recognised social science research on the behavioural response by the public and stakeholders to warnings about natural hazards. Her research has contributed to MetService's severe weather warning system, emergency mobile alerts for the National Emergency Management Agency, and a revised Volcanic Alert Level System for Aotearoa New Zealand.

GNS Science Lifetime Achievement Award

Geophysicist and groundwater scientist **Paul White** won the GNS Science Lifetime Achievement Award. Paul has contributed enormously to protecting Aotearoa New Zealand's freshwater resources since 1980. He is a leading exponent of 3D hydrogeological modelling and has made significant scientific contributions to understanding aquifer structure, rainfall recharge, groundwater-river interaction, geothermal systems, and water economics.

New Fellows of Royal Society Te Apārangi

Principal Scientist and earthquake geologist **Kelvin Berryman** and palaeontologist **James Crampton** were elected as Fellows of the Royal Society Te Apārangi. Kelvin was recognised for his outstanding contribution to advancing the understanding of the processes and hazards associated with plate boundary zones. James, who is now a Professor at Victoria University of Wellington, is internationally recognised for his work on the physical drivers of evolution, and the dynamics of biodiversity, biogeography and biostratigraphy.


1.


2.

Other 2019 awards

Kelvin Berryman was reappointed to the Advisory Board of the United Nations Office for Disaster Risk Reduction for the biennial Global Risk Assessment Report. This is the flagship report of the United Nations on worldwide efforts to reduce disaster risk.

For the fifth consecutive year **GNS Science** was the top-ranked corporate institution in the world for the number and quality of its publications in Earth and environmental science. We also ranked 12th internationally for corporates publishing in natural sciences. The annual *Nature Index* tables are a worldwide measure of high-quality research output by corporates, government and academic organisations.

The **Geotrips website** won the Excellence in Science Communication Award from the Science Communicators Association of New Zealand. Created by Julian Thomson and supported by GNS Science, the website encourages people to visit interesting rock outcrops, geological displays or landforms, as well as make their own geological explorations and discoveries. The award is offered biennially to recognise outstanding communication of science to a non-scientific audience.

Geothermal geologist **Isabelle Chambefort** received the 2019 New Zealand Geothermal Association Contribution Award, for securing large grants to enable Aotearoa New Zealand to look beyond standard geothermal and understand the critical potential of geothermal. This award acknowledges that in the past eight years Isabelle has received almost $12 million in funding from research grants. These have all been dedicated to better understanding the deep source of the geothermal systems and their connection with the magmatic system to better constrain the future use of Aotearoa New Zealand's supercritical resources.

For the third year in a row, a gold rating was awarded to the **Hikurangi Subduction Earthquakes and Slip Behaviour** programme under the MBIE Endeavour Fund. This is a five-year programme targeted at understanding earthquakes and fault slip processes on the Hikurangi subduction zone where the Pacific Plate subducts beneath the North Island. The Hikurangi subduction zone is Aotearoa New Zealand's least understood and potentially largest source of geohazard.

Materials science leader **John Kennedy** was admitted as a Fellow of the Royal Society of Chemistry UK in recognition of his accomplishments and contributions to chemical sciences.

Geologist **Nick Mortimer** was awarded honorary life membership of the Geoscience Society of New Zealand, the ninth recipient and the youngest recipient to date. The award recognises 'meritorious service given to the Geoscience Society for the advancement of the geosciences in New Zealand.' Nick's roles have included Geological Society President, Editor of *New Zealand Journal of Geology and Geophysics*, Curator of GNS Science's Petlab database and promoter of Te Riu-a-Māui / Zealandia. Nick was also appointed this year as an Honorary Research Professor at the University of Otago.

Geophysical statistician **David Rhoades** was made a Fellow of the International Union of Geodesy and Geophysics. David is the first scientist from Aotearoa New Zealand to be awarded this honour. He is best known for his work in leading the development for the medium-term earthquake forecasting method called 'Every Earthquake a Precursor According to Scale' or EEPAS.

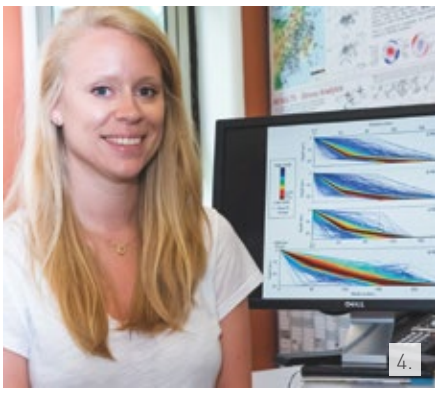
Hazard and risk management researcher **Sally Potter** was part of a team of social scientists who won the 2019 New Zealand Emergency Media and Public Affairs Award for Excellence in Emergency Communication Research. The team investigated the needs, uses and responses of agencies and the public for aftershock information following the Canterbury earthquakes. Their findings have influenced the way GeoNet and United States Geological Survey communicate earthquake forecasts and science advice in large earthquakes.

Geodetic surveyor **Neville Palmer** won the Kingma Award, which is awarded to the most outstanding Earth science technician of the year, for his work using GPS and seafloor instrumentation to observe tectonic deformation.

Geodynamic and tectonic geomorphology researcher **Phaedra Upton** was named the Hochstetter Lecturer for 2020. The Hochstetter Lecture is delivered around the country by an Earth scientist from Aotearoa New Zealand who is undertaking, or who has recently completed, a major and as yet unpublished study, and who has a reputation as a good, informative speaker. Phaedra is only the third woman in the 45-year history of this award to be selected. Phaedra's lecture will bring together many years of research exploring the coupling between tectonics and surface processes, including insights gained from the Southern Alps and more recently the Kaikōura earthquake.

Seismologist **Emily Warren-Smith** accepted the 2019 New Zealand Geophysics Prize for a multi-author geophysics paper published in *Nature Geoscience:* 'Episodic stress and fluid pressure cycling in subducting oceanic crust during slow slip'. Co-authors included Bill Fry, Laura Wallace and Stuart Henrys from GNS Science. This prize recognises the authors of the most meritorious publication in the field of geophysics in the current or previous two calendar years.

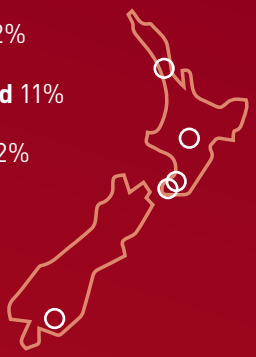
Every year MBIE rates a contract's performance as red, amber, green or gold with gold signifying performance exceeding expectations. Two of our 18 contestable research programmes were given a **gold rating** by the Ministry of Business, Innovation and Employment in 2019. One of these went to Geophysicist and groundwater scientist **Paul White** and his team, working closely alongside Ngāti Rangiwewehi, for their **Vision Mātauranga Capability Fund project**. GNS Science has partnered with Ngāti Rangiwewehi to develop a new approach to water resource management. Ngāti Rangiwewehi are kaitiaki (guardians) of the Awahou stream that flows into Lake Rotorua. Paul's team has worked closely with them on flow regimes that meet the iwi's needs around food-gathering, sustainability, and their economic and spiritual wellbeing. The project is sharing its findings and engaging in outreach with other iwi.



1. Isabelle Chambefort.
2. Nick Mortimer.
3. Neville Palmer.
4. Emily Warren-Smith.

Our
454 staff
are located in

- **Auckland** 2%
- **Wairakei** 13%
- **Avalon** 72%
- **Gracefield** 11%
- **Dunedin** 2%



Visit our website:
www.gns.cri.nz

ABOUT GNS SCIENCE

About us

GNS Science, Te Pū Ao, is an Aotearoa New Zealand Crown Research Institute that unlocks environmental, social, cultural and economic benefits through its work across four Science Themes:

- Natural Hazards and Risks
- Environment and Climate
- Energy Futures
- Land and Marine Geoscience

Our focus on outcomes means an interdisciplinary approach to our research. Our work combines physical sciences with expertise in Data Science, Vision Mātauranga and Social Science. This approach enables a more sustainable environment and better quality of life for New Zealanders.

We connect with stakeholders and collaborators from research, government and industry to build and deliver fit-for-purpose science. This includes partnering with iwi/Māori to explore the science and innovation potential of Māori knowledge, resources and people to benefit all New Zealanders.

Our impacts

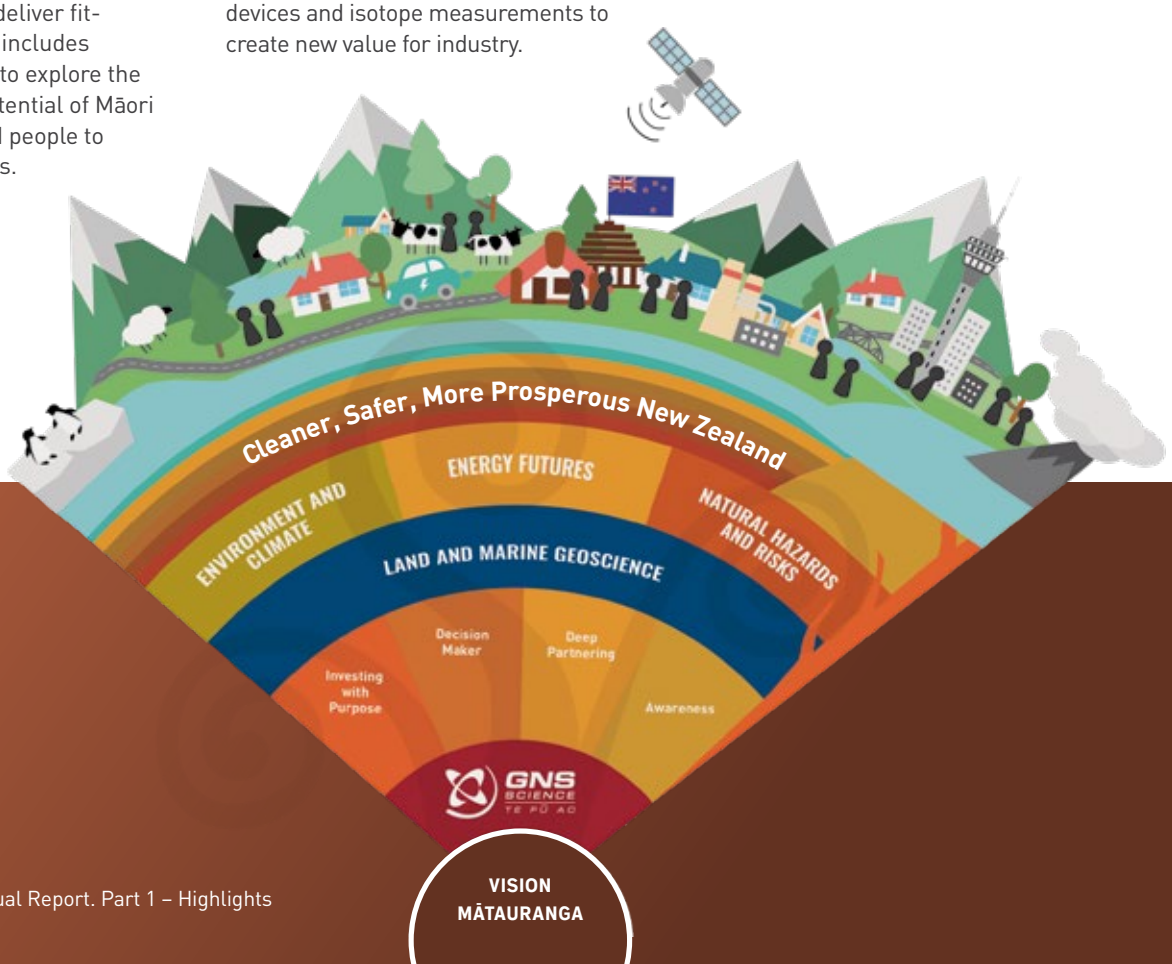
Our expertise contributes to a Cleaner, Safer, More Prosperous Aotearoa New Zealand by:

- building intergenerational wealth and wellbeing through wise custodianship of Aotearoa New Zealand's freshwater, energy and mineral resources
- reducing the physical, economic and societal impacts of geological hazards, including through 'early warning' systems, improved hazard awareness and preparedness, enhanced geohazards monitoring, and enabling more resilient communities, buildings and infrastructure
- understanding past climates to improve global models that predict the future impacts of a changing climate
- developing and applying novel technologies such as nano-scale devices and isotope measurements to create new value for industry.

How we work

Through trusted partnerships with our key stakeholders we:

- Provide expert scientific input to policy, regulation, standards, and guidance
- Provide advice and tools to decision-makers on the effective management of Aotearoa New Zealand's natural hazards, the environment, groundwater, and energy requirements
- Work with business to encourage innovation and productivity, and develop new knowledge-intensive technologies
- Contribute to national and global collaborative science initiatives to enhance capability and science value
- Build on our host role for the Resilience to Nature's Challenges National Science Challenge to strengthen our contribution to the Challenge and aligned research.



SCIENCE THEMES

Providing excellent science, where it matters most

*The **Four Capitals** (natural, human, social, and financial and physical) are the pillars of the NZ Treasury's Living Standards Framework. Together they generate wellbeing now and into the future.

How these impact Aotearoa New Zealand and its people

Research priority areas:
- Managing Risk to the Four Capitals*
- Enabled and Informed Public, Community and Business
- Effective Early Warnings and Forecasts
- Improved Response, Decision-Making and Recovery Planning
- Improved Risk Governance

How people impact the Earth

Research priority areas:
- Our Groundwater Systems
- Antarctica in a 2°C Warmer World
- Ecosystem Response to a Warming World
- Revealing the Drivers of Our Climate
- Carbon Cycle Dynamics
- Our Rising Tide

How we use Earth's resources sustainably and generate new value for Aotearoa New Zealand

Research priority areas:
- Maximising Geothermal Direct Use
- Knowledge of the Deeper Taupō Volcanic Zone
- Reducing Risks Associated with Geothermal Developments
- Kaitiakitanga of Geothermal Ecosystems
- Superhot Geothermal Fluids
- Energy Efficiency and Storage
- Energy Innovations

Underpinning knowledge of Aotearoa New Zealand's geology and how the Earth works

Research priority areas:
- Thermal Processes
- Plate Boundary Tectonic Processes
- Continental Tectonic Processes
- Surface Geological Processes
- Databases/Geoscience Information

OUR SCIENCE

Our data, discoveries and innovations over the past year enable more informed decisions to meet Aotearoa New Zealand's current and future needs.

Left: A technician services GeoNet monitoring equipment adjacent to Mt Ruapehu's Crater Lake.

SCIENCE THEME

NATURAL HAZARDS AND RISKS

We have a national leadership role for monitoring and research on the causes, risks and consequences of geological hazards in Aotearoa New Zealand. By applying our social science capabilities, we help increase community resilience, communication of risks and hazard preparedness.

WHAKAARI / WHITE ISLAND – A TRAGIC ERUPTION

GNS Science played a crucial role in the response to the December 2019 eruption of Whakaari/White Island, where 21 people tragically lost their lives and many were seriously injured. Our staff used their knowledge and understanding of the volcanic activity to support agencies during the response and recovery.

As soon as it became clear that people were on the volcano when it erupted, the tragic consequences were topmost in our minds. Months later, our thoughts continue to be with the people who died, those who were seriously injured, and the families and whānau of everyone involved on that day.

Our volcanology experts based at the Operations Centre in Whakatāne and in the National Crisis Management Centre in the Beehive in Wellington provided regular updates on the state of volcanic activity at the Island. Elsewhere, our staff provided information and updates to central and local government and communicated with the public via mainstream and social media.

We acted as a specialist science advisor to support the all-of-government response, which included the National Emergency Management Agency (NEMA), the Police and the New Zealand Defence Force.

The eruption

Between May 2016 and December 2019, Whakaari/White Island had mostly been at Alert Level 1, indicating minor volcanic unrest. In late June 2019 we raised the Alert Level briefly to 2 when the volcano experienced moderate unrest. After a subsequent period at Level 1, we raised the Alert Level again to 2 in mid-November.

The volcano remained very unpredictable for some weeks after the eruption, and it was not until after Christmas 2019 that we saw gas emissions and seismic activity starting to drop back towards background levels.

How we monitor volcanic activity at Whakaari/White Island

Through its GeoNet project, GNS Science continuously monitors volcanic activity at Whakaari/White Island. Methods include webcams, seismometers (earthquake activity), UV spectrometers (sulphur dioxide emission rates) and GPS (for ground deformation). We monitor these datastreams round the clock at the National Geohazards Monitoring Centre *Te Puna Mōrearea i te Rū*, and this information is complemented by the use of satellite techniques to monitor ground deformation and sulphur dioxide emission rates at regular intervals.

Our scientists regularly fly around the volcano to measure emission rates of a range of gases. Prior to the 9 December eruption, we visited the Island at intervals of one to three months to collect gas and water samples, collect other geophysical data, and make general observations. Our techniques – monitoring of earthquakes, ground deformation, gas emissions and visual observations – are common monitoring techniques used by leading volcano observatories worldwide. All our monitoring activities are carried out within strict health and safety protocols and we are continuing to develop unmanned aerial vehicle capabilities as an integral part of our work.

Our role is to explain what our monitoring and observations tell us and provide insights. We will continue to study what happened during the eruption to learn as much as we can, but we will not forget its tragedy – the lives lost, those injured and their families who will never be the same.

"In the wake of the eruption, I worked closely with key volcanologists, especially Dr Graham Leonard and Dr Nico Fournier of GNS Science, whose expertise, dedication and tenacity were crucial in recovery efforts."

Professor Juliet Gerrard, Prime Minister's Chief Science Advisor.

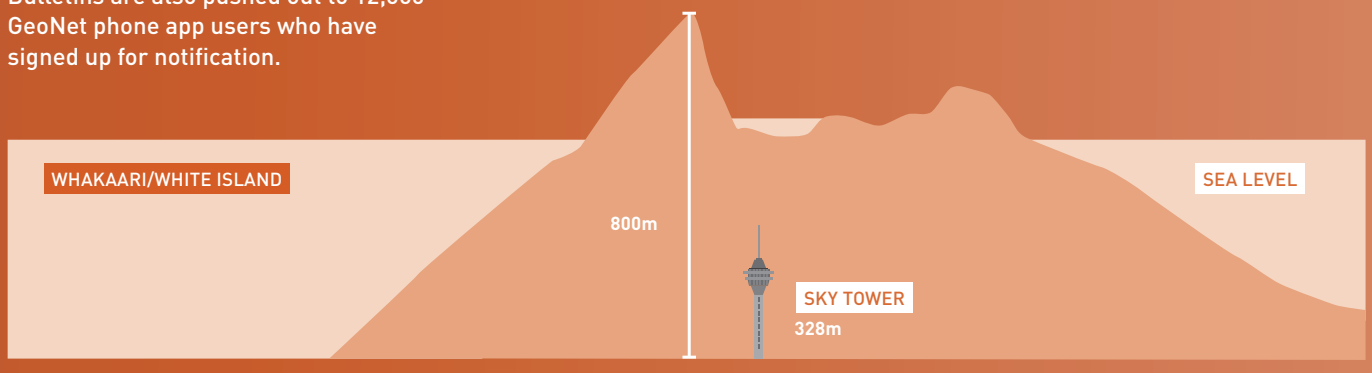
Communicating the hazard

We communicate the status of activity at our volcanoes to the public and government agencies through a six-stage Volcanic Alert Level (VAL) system. The VAL only communicates the current activity at the volcano – it is not a predictor of risk and does not provide a forecast of future activity. VAL changes are communicated through Volcanic Alert Bulletins which are Aotearoa New Zealand's official source of volcano status information. We distribute the Bulletins through the GeoNet website, Facebook and Twitter, and via email. Bulletins are also pushed out to 12,000 GeoNet phone app users who have signed up for notification.

Background on Whakaari/White Island

Whakaari/White Island is a strato-volcano, also known as a cone volcano. It sits 48 kilometres off the Bay of Plenty coast and is one of Aotearoa New Zealand's most active volcanoes. It has been built up by continuous volcanic activity over the past 150,000 years. About 70 percent of the volcano is under the sea and its total size is about half that of Mt Taranaki, Ruapehu, or Tongariro.

There has been continual low level activity, and some eruptions, at Whakaari/White Island since human settlement of Aotearoa New Zealand. Typically it produces short-lived explosive, steam-driven or hydrothermal eruptions.



NATURAL HAZARDS AND RISKS

Mission critical for a shaky country: revised seismic hazard model for Aotearoa New Zealand

Providing up-to-date, useful information for decision-makers is vital when it comes to managing Aotearoa New Zealand's risks from seismic events.

The National Seismic Hazard Model assesses the likelihood and strength of earthquake shaking occurring at any given point in Aotearoa New Zealand – and this year GNS Science embarked on a revision.

The model incorporates the best available science to deliver estimates of earthquake shaking over selected time periods. It is widely used by industry and government to estimate the impact of this shaking on land, buildings and infrastructure, and plan accordingly.

Key users include MBIE, EQC, local and regional authorities, NZTA, structural and geotechnical engineers, land-use planners, seismic hazard consultants and risk modelling consultants, and the insurance sector.

> **"This is mission-critical data for decision-making to reduce the impact of earthquakes on New Zealand homes, communities, towns and cities."**
> Dr Jo Horrocks, Chief Resilience & Research Officer, Earthquake Commission

It will help us understand the expected shaking that might occur in a specific area over a certain amount of time, for example, the next 10, 50 or 100 years, providing a better picture of earthquake risk in different parts of Aotearoa New Zealand.

The information it provides is essential for Aotearoa New Zealand to build resilience and manage risks to safety, security, and the economy from seismic events. It underpins decisions about road and rail infrastructure development, civil defence planning, assessing risk by insurance companies, determining how buildings need to be built, and more.

The revision will reflect research knowledge gathered over the past two decades, including from the Canterbury and Kaikōura earthquakes.

A team of local and international scientists and expert end-users is contributing to the project which is a joint initiative by GNS Science, MBIE and EQC. The revised National Seismic Hazard Model is expected to be completed in mid-2022 and will be freely available online.

Top: Damage to SH1 and the main north-south railway at Waipapa Bay in Marlborough from the M7.8 Kaikōura earthquake in November 2016.

SNAPSHOT

2 decades
Revision reflects research knowledge gathered over the past two decades

Provides a better picture of earthquake risk

Project team consists of local and international scientists, and expert end-users

2022
Revised model is expected to be completed in mid-2022

NATURAL HAZARDS AND RISKS

RiskScape – users help shape the future of risk modelling

Our world-leading risk modelling tool, RiskScape, was further developed over the past year, as GNS Science continues to work with project partners NIWA and the Earthquake Commission (EQC) towards a new version of the software.

RiskScape is modelling software that lets users assess risk to buildings, infrastructure and people from natural hazards such as earthquakes, tsunamis and floods. The tool is based on open source technology, providing access for researchers and people working in disaster risk management to improve understanding of natural hazard risks in Aotearoa New Zealand and further afield.

EQC selected RiskScape to replace their existing loss modelling tool, pooling resources with NIWA and GNS Science to work on the next version – RiskScape 2.0 – which will be a web application. The development of a web-based user interface will make RiskScape more accessible for government, councils, insurance and reinsurance users, as well as our existing researcher base.

The RiskScape team ran nationwide workshops and an online survey with end-users. We asked how they like to interact with risk modelling tools, what functionality they would like, and how they use the outputs. This information will be published for other developers to use. We also developed a translator function for a multilingual RiskScape and are testing it in te reo Māori.

With a wide range of end-users, the uses for RiskScape are extensive. They include, for example, cost-benefit analysis for roading options, understanding the impact of future natural hazard events in regions, land-use planning and policy, and many more.

> **"RiskScape is allowing us to undertake a much more detailed analysis of policy options for managing risk from natural hazards than we could otherwise have done. This provides a high degree of robustness to our assessment, which is essential for a publicly contested RMA process."**
> Emily Grace, Senior Policy Planner, Queenstown Lakes District Council

For more information on RiskScape software, see bit.ly/riskscape

Top: The updated risk modelling tool, RiskScape, will be more accessible for a wide range of end-users who model the impact of earthquakes on cities such as Wellington (above).

SNAPSHOT

Tool is based on open source technology

Nationwide workshops and online surveys run to help develop the new risk modelling tool

Multilingual translator function being tested in te reo Māori

NATURAL HAZARDS AND RISKS

Science scenarios inform major infrastructure investment in Wellington region

If a magnitude 7.5 earthquake occurs any time soon on the Wellington Fault, the Wellington Lifelines Group estimates the economic impact on Aotearoa New Zealand would exceed $16 billion.

GNS Science was closely involved in a three-year regional resilience project, aimed at reducing that impact through smart investment in infrastructure.

The Lifelines Group was chaired by Dame Fran Wilde and comprises the Wellington region's councils, power, water, rail, road and port companies, Wellington Airport and GNS Science.

Its infrastructure investment business case, released in December 2019, calls for major investment in the region's infrastructure.

GNS Science's expertise in risk modelling was central to the final business case. RiskScape and MERIT software were used to model the region's resilience and subsequent economic disruption after a large earthquake. The GNS Science team worked with partners Market Economics and Resilient Organisations to evaluate the effectiveness of a range of proposed infrastructure investment options.

> **"The prize for getting this right will be a highly resilient Wellington: future-proofing an important part of New Zealand."**
> Dame Fran Wilde, Chair, Wellington Lifelines Group

The headline: a coordinated $3.9 billion investment in the Wellington region's infrastructure would save the nation $6 billion in the aftermath of a significant earthquake occurring in the region. Three phases of investment are proposed over a 20-year period including across the fuel, transport, electricity, telecommunications, water and gas sectors.

This piece of work lays out a blueprint for the future resilience planning of the Wellington region, which could be translated to Aotearoa New Zealand's other metropolitan cities. It also demonstrates the importance of a coordinated approach to infrastructure investment to help cities survive and thrive after a major natural disaster.

Top: A proposal by Wellington Lifelines Group to invest $3.9 billion in infrastructure improvements in Wellington would save the nation $6 billion in the event of a significant earthquake in the region.

SNAPSHOT

$16 billion
A magnitude 7.5 earthquake on the Wellington Fault would cause an economic impact exceeding $16 billion

$3.9 billion
An investment of $3.9 billion would save the nation $6 billion

3 phases
of investment are proposed over a 20-year period

NATURAL HAZARDS AND RISKS

Sharing knowledge, building resilience

In building resilience to natural hazards, iwi and hapū management plans (IHMPs) can be highly influential, GNS Science research has shown.

These plans are created by iwi and hapū, and lodged with councils to inform and influence planning processes in their region.

Our social science researchers wanted to understand how the plans contribute to managing risks from natural hazards, how our science information is making its way into the plans, and how researchers can use the plans to inform their research direction.

In a study in the Bay of Plenty, we found a mix of natural hazard information in IHMPs. Their perceived value by councils and their acknowledgement in district plans was variable. However, the IHMPs have the potential to be very influential documents for planning, policy and research. They can be effective in interweaving indigenous knowledge, practices and aspirations with statutory planning processes for natural hazard risk management.

Based on a small sample of researchers, we found a lack of awareness of IHMPs and how they could be used. Many were not aware that IHMPs are highly valuable documents for informing research direction and priorities that are aligned with those of iwi. For example, the plans outline iwi or hapū issues, priorities, and they have environmental and resource-based objectives, methods and actions.

In addition, they often outline the iwi's preferred engagement process. IHMPs provide researchers with an important first step when considering the Vision Mātauranga component of their research.

Further effort is required by councils, natural hazard researchers, CRIs and universities to make hazard information more accessible for iwi.

Following the study, GNS Science has been strongly advocating the use of IHMPs with researchers, councils and central government agencies via conferences and seminars, as well as publishing papers with recommendations for using these plans to improve natural hazard management, inform research directions, and as a starting point for engagement. Greater cross-pollination of knowledge between researchers and iwi/hapū about natural hazards risk management is the desired outcome.

This work was funded by the National Science Challenge 'Resilience to Nature's Challenges' Mātauranga Māori programme.

Top: Iwi and hapū management plans help interweave indigenous knowledge into natural hazard risk management.

SNAPSHOT

IHMPs
are iwi and hapū management plans

IHMPs have huge potential for informing researchers, councils and others about iwi priorities

GNS Science has been strongly advocating the use of IHMPs with researchers, councils and central government

NATURAL HAZARDS AND RISKS

Better monitoring and detection of tsunamis in the Southwest Pacific

Aotearoa New Zealand will get improved warning of tsunamis generated in the Southwest Pacific thanks to the phased deployment of 12 deep ocean tsunami sensors to the north and east of the country. Nine have already been deployed and the rest are scheduled to be in place in the next 12 months.

GNS Science and NIWA are both providing specialist input into the initiative, which is being funded by the Government and led by the National Emergency Management Agency (NEMA). It represents the biggest single growth in tsunami monitoring in this part of the Pacific region in decades.

> **"The establishment of the DART Buoy network is a significant boost to New Zealand's end-to-end arrangements for monitoring, detecting and issuing warnings about tsunami threats. The network will help keep people safe by enabling faster detection and more accurate warnings of tsunami threats."**
> Sarah Stuart-Black, Director, Civil Defence and Emergency Management

The best way to quickly forecast tsunami impacts and reduce the effects on people and property is through a combination of data from earthquake instruments and from Deep-ocean Assessment and Reporting of Tsunami (DART) buoys. These buoys are being deployed at selected points adjacent to the Hikurangi, Kermadec, Tonga, and New Hebrides trenches where they will be able to detect tsunamis that could reach our shores in less than two hours.

The instruments are fourth generation DART buoys which have more advanced sensors, and better software and power management systems than earlier models. This gives them enhanced ability to detect and measure tsunamis generated by earthquakes or other sources, thus giving faster information to scientists and agencies that disseminate warnings and advisories to the community.

GNS Science's 24/7 National Geohazards Monitoring Centre *Te Puna Mōrearea i te Rū* will receive and analyse data from the buoys. The Centre will then provide information and analysis to NEMA which will issue advisories and warnings to the public. The network will provide monitoring and detection information for Tokelau, Niue, the Cook Islands, Tonga and Samoa.

Data from the network will be streamed live to the Pacific Tsunami Warning Center to enhance trans-Pacific forecasts, providing benefits to all countries surrounding the Pacific Ocean.

The new deep-sea array will enable better warnings and provide more accurate estimates on how big the waves could be when they reach our coast. The sensors are particularly valuable for monitoring potential tsunamis from earthquakes in the Southwest Pacific that may be unfelt on the mainland of Aotearoa New Zealand.

DART buoys are currently the only way to rapidly confirm a tsunami has been generated before it reaches the coast. Just as important, they will also provide rapid information when no tsunami has been generated after a large earthquake, or other possible trigger events such as under-sea landslides and volcanic eruptions.

Top: A DART buoy for detecting tsunamis being deployed from NIWA's research ship *Tangaroa.*

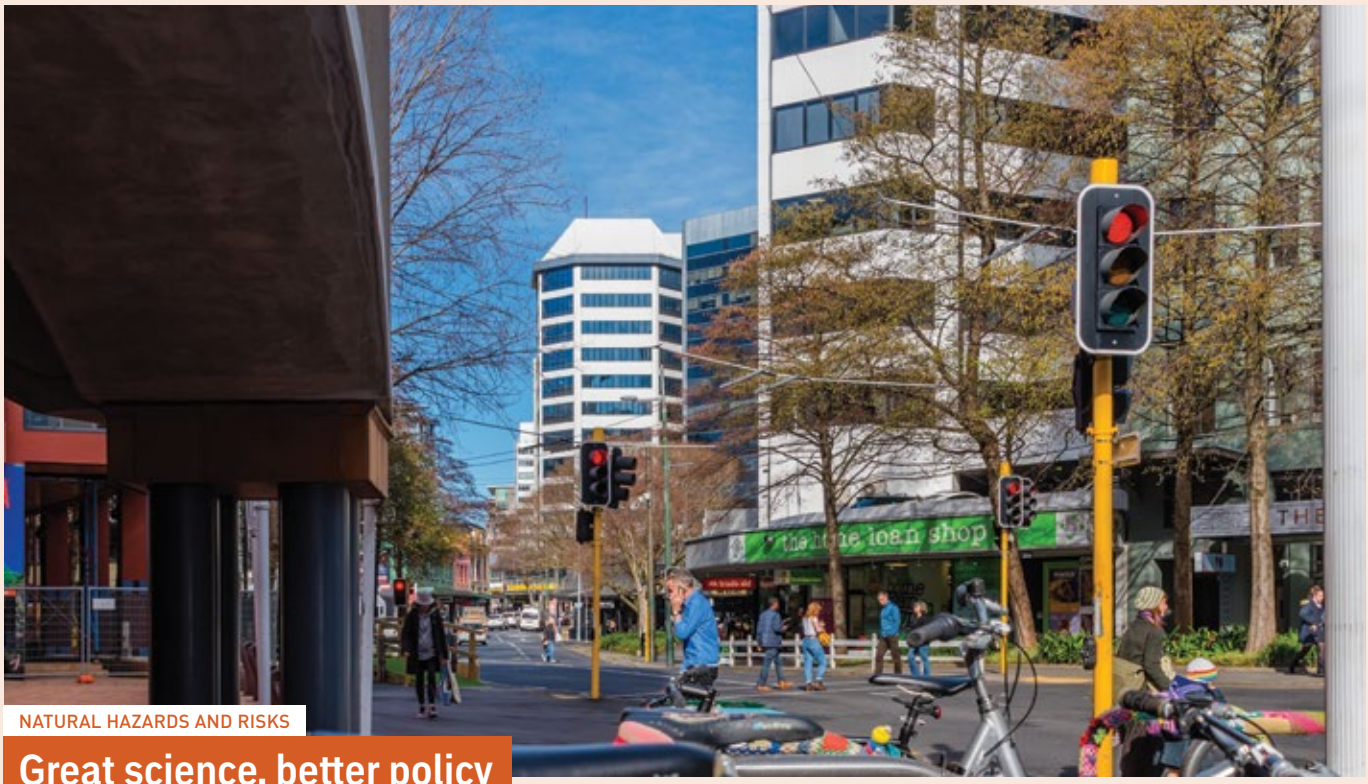
SNAPSHOT

9
Deep ocean tsunami sensors have been deployed

12 months
The remaining 3 sensors are to be deployed over the next 12 months

< 2 hours
Will be able to detect tsunamis that could reach our shores in less than two hours

Data from the network will be streamed live to the Pacific Tsunami Warning Center



NATURAL HAZARDS AND RISKS

Great science, better policy

Natural hazards and risks must be properly considered when national and local government policy is developed. To ensure the best possible advice was available to decision-makers, GNS Science provided expert input into key pieces of work over the past year.

In many cases, we suggested amendments to improve environmental outcomes and the management of the significant risks associated with natural hazards.

Our input highlighted the importance of natural hazard risks being fully accounted for and balanced with climate change impacts.

This work included:

- Contributing to the comprehensive overhaul of the Resource Management Act 1991. We participated in two groups reviewing the Issues and Options paper released by the RMA Review Panel.
- Presenting to the Environment Select Committee on the Climate Change Response (Zero Carbon) Amendment Bill, discussing the National Adaptation Plan and greenhouse gas emissions and targets.
- Being part of the Ministry for the Environment's panel of experts developing Aotearoa New Zealand's first National Climate Change Risk Assessment framework. This framework provides the means to evaluate risks and opportunities from climate change in terms of their nature, severity and urgency.
- Submitting on the Government's COVID-19 Recovery Bill for establishing a fast-tracking process for projects and enabling variations to existing and planned infrastructure projects.
- Making a submission on the proposed National Policy Statement on Urban Development 2019 which provides direction for local government.
- Feedback on the National Emergency Management Centre's draft guidance for risk assessment in Civil Defence group planning.
- Submitting on the Auckland Council's Climate Change Risk Assessment Framework, which is designed to reduce emissions and increase resilience for the region. We suggested areas to strengthen and identified useful research.

Top: We provided expert input to local and national government policy development to ensure natural hazards and risks are properly accounted for.

SNAPSHOT

Provided expert input into key pieces of work

Part of MFE's panel of experts developing NZ's first climate change risk assessment framework

Participated in the overhaul of the Resource Management Act

NATURAL HAZARDS AND RISKS

A prototype tool for landslide forecasting

GNS Science is developing a series of tools that will forecast the likely location and size of earthquake- and rainfall-induced landslides to provide rapid information for responding agencies and infrastructure operators. A prototype earthquake-induced landslide forecast tool is being used by GeoNet landslide duty officers, and we are continuing with its development. It is hoped the rainfall-induced landslide tool and the landslide runout tool will be operational in 2021 and 2022 respectively.

The tools are designed to produce information on the likely location, extent and impacts of landslides within minutes of a large earthquake, or in the days and hours before a major storm is likely to hit Aotearoa New Zealand.

Major inputs for the earthquake-induced landslide tool are ground shaking data recorded by the GeoNet network, slope angle, slope curvature, distance to fault and surface materials.

"Knowing the likely location, extent and impacts of landslides will be invaluable to EQC in planning our response to significant natural disasters. This information will allow us to deploy appropriate resources quickly and efficiently, which ultimately supports a better recovery for our customers."

Mike Tyson, Operational Advisor, Strategic Partnering, Readiness & Recovery, Earthquake Commission

The impetus for the tool was the magnitude 7.8 Kaikōura earthquake in November 2016 where our landslide specialists invested a lot of time looking for landslides before they were able to identify where the most severe impacts were.

These tools are not intended to forecast the precise location of landslides, but rather to provide information to help 'first responders' to identify critical areas that could be affected. It will also help scientists with reconnaissance missions.

Information from the tools will be generated within our National Geohazards Monitoring Centre *Te Puna Mōrearea i te Rū* and shared with the National Emergency Management Agency. Funding for this work is provided by the Government's Endeavour Fund and through GeoNet's operational budget.

Top: Major landslides, such as this one blocking SH1 at Ohau Point north of Kaikōura after the M7.8 Kaikōura earthquake, can take many weeks to clear.

SNAPSHOT

2
Landslide tools hoped to be operational by 2022

7.8
Magnitude 7.8 Kaikōura earthquake was the impetus for the tool

Tools will help first responders to identify critical areas that need priority attention

NATURAL HAZARDS AND RISKS

Resilience to Nature's Challenges

GNS Science is proud to host Resilience to Nature's Challenges Kia manawaroa – Ngā Ākina o Te Ao Tūroa. It's one of 11 National Science Challenges established to tackle big issues that affect all New Zealanders. The mission of the Resilience Challenge is to accelerate Aotearoa New Zealand's natural hazard resilience.

Phase 2 of the Challenge pairs exciting new research to advance our understanding of natural hazards with mātauranga Māori, social science and engineering research, to develop policies and tools that reduce the social and economic impacts of future natural hazard events.

Phase 2 started in July 2019 and, one year in, researchers are well underway with their five-year research programmes. We are engaging end-users from the outset to ensure research outputs are useful and usable, and workshops with partners and stakeholders have been run across the country to build relationships and set expectations.

Research leaders have been busy recruiting and supporting the first tranche of nearly 70 Challenge-funded PhD students – an investment that will significantly boost capability in the natural hazard research field.

Many Challenge researchers have been active in the science response to the COVID-19 pandemic, providing advice to central government on social and economic recovery, and how to best steer our national recovery so we build resilience to future shocks.

Another focus has been expanding mātauranga Māori capability in our programmes and in the Challenge as a whole. This was assisted by the recruitment of a Vision Mātauranga knowledge broker to support research programmes with their iwi engagement and upskill the entire Challenge whānau through a series of wānanga. This mahi has been further supported by the publication of a new Guide to Vision Mātauranga, developed by all 11 National Science Challenges and Ngā Pae o te Māramatanga, Aotearoa New Zealand's Māori Centre of Research Excellence.

The Resilience Challenge, supported by host organisation GNS Science, is well placed to embark on an exciting year of research, partnerships, capability enhancement and science communication.

Top: Tsunami evacuation and awareness signs are now commonplace on exposed coasts such as this one at Tora, Wairarapa.

RESILIENCE TO NATURE'S CHALLENGES | Kia manawaroa – Ngā Ākina o Te Ao Tūroa | National SCIENCE Challenges

SNAPSHOT

11
One of 11 National Science Challenges

Phase 2
Phase 2 started in July 2019

70
Research leaders have been recruiting and supporting nearly 70 PhD students

COVID-19
Many Challenge researchers have been active in the science response to COVID-19

SCIENCE THEME

ENVIRONMENT AND CLIMATE

Our research focuses on groundwater resources, sea level rise, the carbon cycle and climate change impacts on ecosystems. Working with our major partners, we have designed our programmes to meet their current and future needs.

MAPPING AQUIFERS FROM THE AIR TO SECURE WATER FOR THE FUTURE

An ambitious project in Hawke's Bay has seen experts take to the air to map water under the ground in Aotearoa New Zealand's biggest ever aquifer mapping project. This forms part of a wider groundwater work programme that includes national aquifer characterisation and advancing groundwater numerical modelling methodologies. GNS Science has partnered with Hawke's Bay Regional Council on the multi-year initiative that will help to protect the region's underground freshwater resources for future generations.

Groundwater Alliance

As part of our work on this precious resource, we are a founding partner of the Groundwater Science & Research Alliance Aotearoa. Fellow partners are ESR, Aqualinc, and Lincoln Agritech. The aim of the Alliance is to raise the profile of groundwater issues in Aotearoa New Zealand and to secure long-term funding that will enable research findings that will make a material difference. In consultation with regional and national water managers, the Alliance has identified gaps in groundwater knowledge, the solutions required, and the investment needed to deliver these solutions.

Aotearoa New Zealand's largest export-earning sectors – tourism and land-based industries – rely on freshwater, with irrigation from groundwater alone contributing about $2 billion to the economy annually. Forty percent of New Zealanders rely on fresh groundwater for their drinking water, and yet up to 40 percent of our freshwater catchments face significant shortages and contamination. This results in significant costs and disruption to remedy. Groundwater is also critical to sustain our aquatic ecosystems and cultural values such as mahinga kai, as 80 percent of our annual river flows come from groundwater.

Our research in this area aligns with a number of relevant international, national and sectoral commitments, strategies and goals, including the National Policy Statement for Freshwater Management, the National Drinking Water Standards, and the Living Standards Framework.

Our aim is to map, measure, and model Aotearoa New Zealand's major aquifers to improve the characterisation, measurement, and dynamic modelling of our groundwater systems. The knowledge we gain can be applied to sustain and improve the social, environmental and cultural values of the nation's aquifers. Through our *National aquifer characterisation by system* project we are developing advanced groundwater maps in both 2D and 3D. Mapping has taken place not by region, but by groundwater system, with the goal of seamless characterisation from the local to the national scale. Through our *Advanced Framework for Groundwater Modelling* project we are developing optimised decision-making tools that can be more easily applied by regional councils and rolled out nationally.

Outputs will be applicable to a diverse range of users including policy-makers, planners, water managers, and hydrogeologists.

What we have been doing

Through previous core and contestably funded programmes, we have been building towards these objectives for more than 10 years. Over the past two years, we have contributed to a national top-down approach of all coastal aquifer systems. This is in terms of fluxes, geometry, classification, and 3D classification in relation to depth to basement rocks.

Central to the Hawke's Bay project is the Danish airborne electromagnetic survey technique known as SkyTEM, which can cover large areas of ground quickly and cost effectively to provide high levels of detail on the subsurface.

The SkyTEM technology provides a 3D view of the subsurface to a depth of about 300m – a bit like getting a scan of the aquifers. It is sensitive to rock type, porosity, permeability, clay content, moisture content, and properties of water – all of which help in understanding aquifers and contribute to our mapping and characterisation of aquifers.

In early 2020, data for the project was collected by a specially equipped helicopter using flight lines that were about 200m apart. Areas covered were the Heretaunga Plains, the Ruataniwha Plains, and the Ōtāne and Poukawa Basins.

We worked closely with the Regional Council to plan the project and liaised with specialist contractors to ensure the surveys were fit for purpose and the data was of a high standard.

"SkyTEM and the 3D Aquifer Mapping project is a major part of our critical water security programme in Hawke's Bay, and it wouldn't be happening without the impetus and support from GNS Science."
Dr Jeff Smith, Manager Science, Hawke's Bay Regional Council

Increasing capability

Although our scientists have significant experience with other electromagnetic methods, this is the first time SkyTEM data has been processed within Aotearoa New Zealand. The technique and equipment were developed by Aarhus University HydroGeophysics Group in Denmark, and GNS Science has partnered with the University to provide training for scientists and quality assurance on the processing and modelling of the data.

Benefit to Aotearoa New Zealand

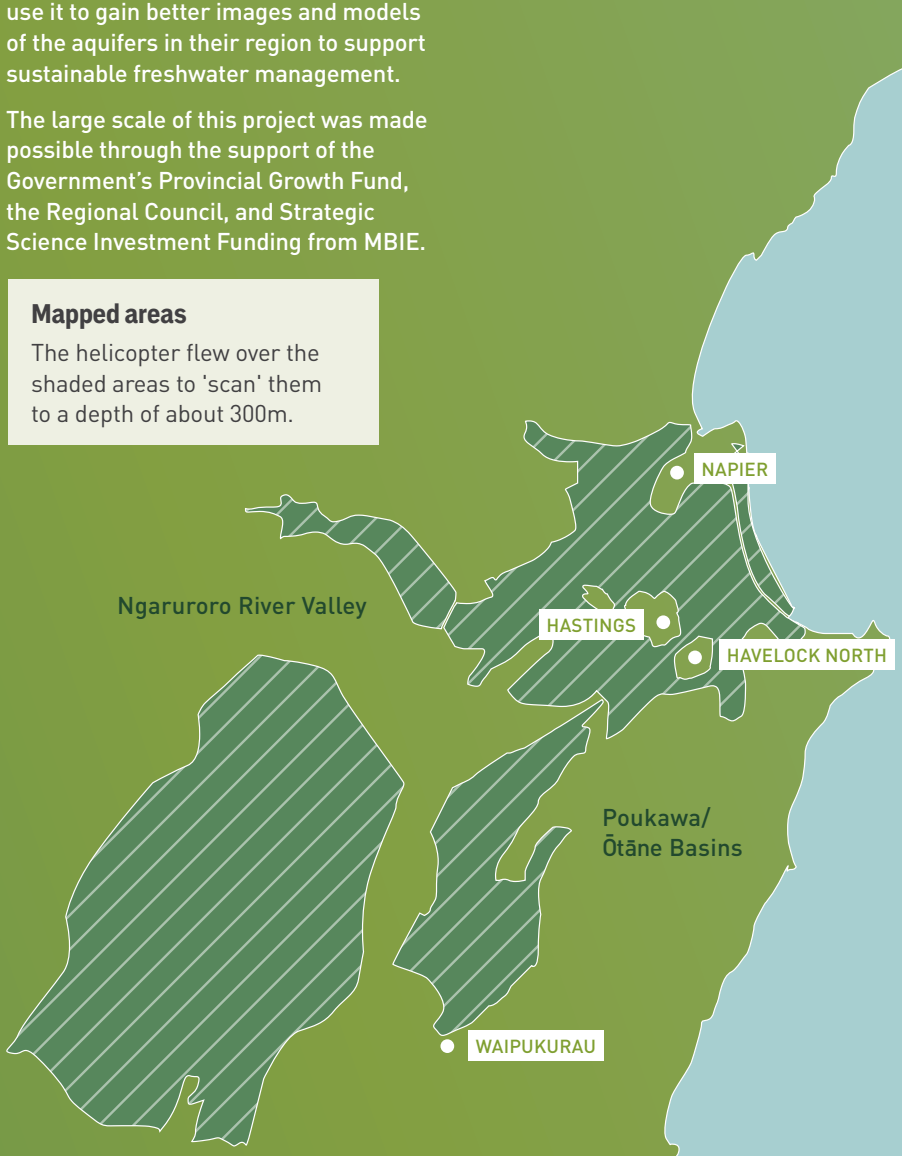
We are making the processed data available to the Council in phases over the next two years, and much of it will be publicly available. In the next year, we will also work with the Council to drill several boreholes in the aquifers for scientific measurements that will be used to ground-truth the data and make the end result more robust. The final year of the project will include updating the Council's groundwater modelling tools in the Heretaunga Plains with this information.

The collected data and derived models will be a long-term asset for the Regional Council to support their freshwater management objectives.

The SkyTEM technique is increasingly being used worldwide to address groundwater management issues. Other councils are expected to follow the lead of Hawke's Bay Regional Council and use it to gain better images and models of the aquifers in their region to support sustainable freshwater management.

The large scale of this project was made possible through the support of the Government's Provincial Growth Fund, the Regional Council, and Strategic Science Investment Funding from MBIE.

Mapped areas
The helicopter flew over the shaded areas to 'scan' them to a depth of about 300m.



ENVIRONMENT AND CLIMATE

An atlas of underground water: protecting precious groundwater

New 3D models of Aotearoa New Zealand's groundwater resources will be crucial for better management of this vital resource. The digital Groundwater Atlas uses nationally-consistent methods to describe our current knowledge of groundwater quality, quantity, flows, locations and drinking water security assessments.

Produced by GNS Science for the Ministry for the Environment, the Atlas and models are the first national resource developed at a consistent and convenient scale for groundwater managers, policy-makers and scientists. We have completed 12 of the models covering various sub-regions of the country and more will be added as the project continues.

Groundwater accounts for 26 percent of Aotearoa New Zealand's drinking-water and its economic value from irrigation alone is estimated at $2 billion a year. To ensure its sustainable management now and in the future, central and local government need to know where it is, how much there is, how it moves through aquifers, its quality and any seasonal variations.

The Groundwater Atlas brings together this information in a consistent national format. It includes features such as a vastly improved and nationally-consistent 2D map of aquifer boundaries, the location of drinking water wells supplying more than 100 people, and the hydraulic properties of aquifers that control groundwater flow.

In developing the Atlas, we improved existing information and made it readily available for a range of important uses, including national-scale environmental reporting.

The unique capabilities of our Hydrogeology group put them in an ideal position to lead the project. They have been responsible for monitoring groundwater quality at a national scale since 1998 and spent several decades working on projects that led up to the development of this initiative.

The Atlas will inform multiple workstreams across the Ministry for the Environment for environmental reporting and management of freshwater. This includes allocation, groundwater and surface water interactions, groundwater quality and limit-setting. It will also increase public awareness about groundwater and help identify information gaps to support future work at national and regional scales. In due course, we will update the Atlas as new information becomes available.

GNS Science led the project in association with ESR, NIWA and independent research provider Aqualinc Research Ltd. The Atlas and supporting documents are available on the Ministry for the Environment website www.mfe.govt.nz/publications/fresh-water/new-zealand-groundwater-atlas-hydrogeological-unit-map-of-new-zealand.

Top: Blue Springs at Te Waihou Walkway, Putaruru, Waikato.

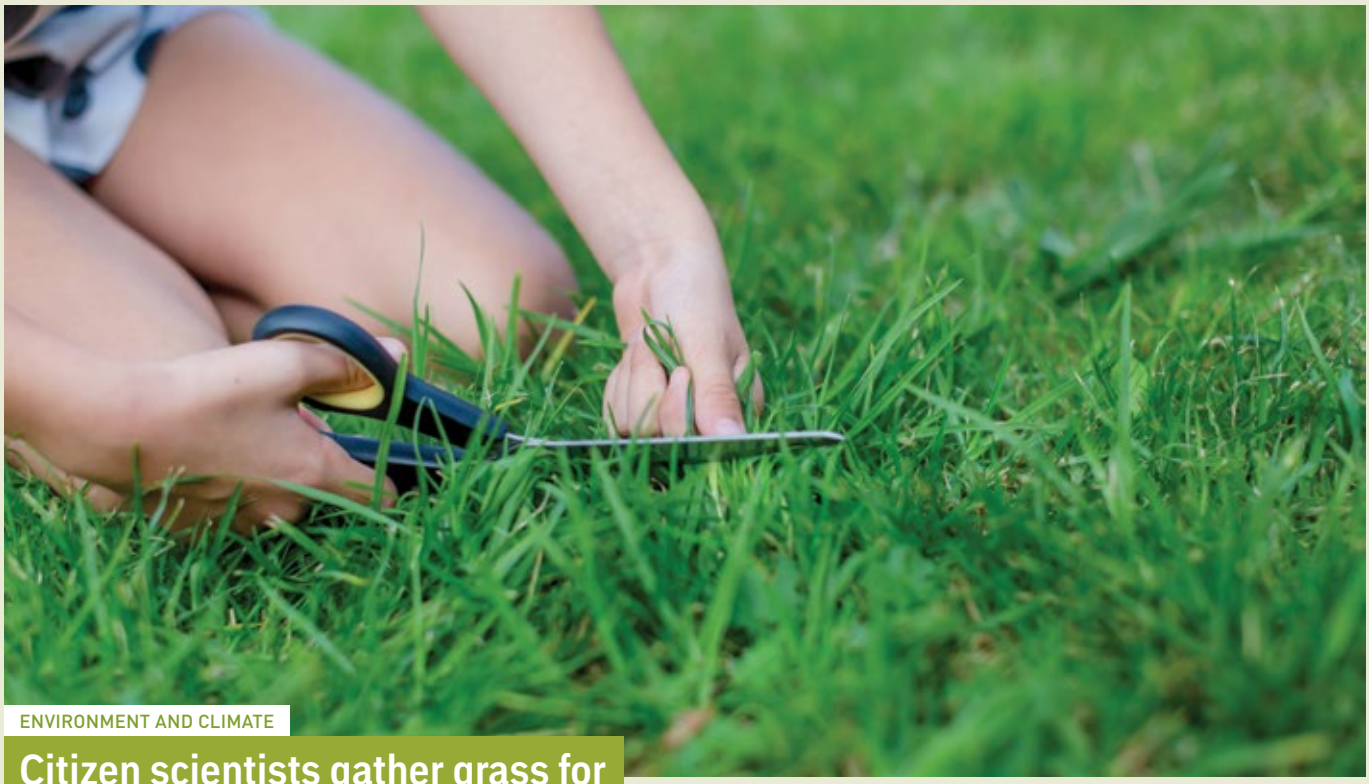
SNAPSHOT

12
We have completed 12 models so far

26%
Groundwater accounts for 26% of Aotearoa New Zealand's drinking water

$2 billion
Economic value for irrigation alone is estimated at $2 billion per year

1998
Our Hydrogeology group has been monitoring groundwater quality at a national scale since 1998



ENVIRONMENT AND CLIMATE

Citizen scientists gather grass for greenhouse gas research

As New Zealanders were confined to their homes during the COVID-19 lockdown, our scientists gave them a job to do: collect grass from their back gardens so our experts could measure the lockdown's impact on greenhouse gas emissions.

Traffic is the largest source of fossil fuel carbon dioxide in Aotearoa New Zealand's cities. The lockdown offered an unprecedented opportunity to test how well our atmospheric measurements can detect emission reductions planned under the Climate Change Response (Zero Carbon) Amendment Act 2019. It was also an opportunity to observe the changes in emissions during this period.

> **"Like the team at GNS Science, we're interested in understanding how the lockdown affected greenhouse gas emissions, as well as the wider environment. The Radiocarbon Lab at GNS Science was creative and responsive, showing great agility to take advantage of an unprecedented situation in order to better understand our world."**
> Dr Nancy Golubiewski, Principal Scientist, Ministry for the Environment

Unfortunately, our plans to install long-term measurement sites in Auckland were delayed by the lockdown. We temporarily deployed these instruments at our Lower Hutt site and sent flasks for Auckland colleagues to fill with air when lockdown moved to Level 3. But even this would miss the most dramatic reductions in emissions.

Luckily, this is where our citizen scientists could step in. Via social media, we enlisted people in the Great Greenhouse Gas Grassoff. The mission: to collect grass clippings locally every week over a 10-12 week period.

Grass uses carbon dioxide from the air to grow and records the radiocarbon in that carbon dioxide. This can be measured to find out the amount coming from fossil fuel burning – petrol, diesel, natural gas and coal. Around 400 citizen scientists got involved, including families and children.

Testing the clippings enables us to measure changes in carbon dioxide emissions as the country gradually moved out of full lockdown, providing valuable insights for the NIWA-led MBIE-funded Endeavour programme CarbonWatch NZ and wider climate change research.

First results indicate that recently added fossil fuel carbon dioxide at some urban sites was about 80 percent lower during Level 4 than in Level 2, consistent with the drop in traffic. Knowledge gained from this work is being shared with seven cities across North America.

Informing policy-making

GNS Science is part of the five-year CarbonWatch NZ project combining measurements of greenhouse gases in the air with models showing where the gases came from. Being able to measure greenhouse gas emissions and characterise their sources will help us determine how Aotearoa New Zealand's emissions are tracking and what policies are having an effect.

CarbonWatch NZ is funded through the MBIE Endeavour Fund. It involves our partners NIWA, Manaaki Whenua-Landcare Research, the University of Waikato and Auckland Council. Together we are building a complete top-down picture of Aotearoa New Zealand's carbon balance, the first country in the world to develop this national-scale picture.

Top: Citizen scientists from throughout Aotearoa New Zealand contributed to the Great Greenhouse Gas Grassoff project.

ENVIRONMENT AND CLIMATE

South Dunedin's groundwater – a national test case for coastal communities

A GNS Science-led study suggests that South Dunedin is less vulnerable to groundwater movement than may have been initially feared. This will enable a wider range of short to medium-term engineering options to mitigate the problems of rising groundwater and surface flooding.

The study is seen as a blueprint for helping to mitigate the impact of sea level rise and rising groundwater levels in low-lying coastal areas throughout Aotearoa New Zealand.

Dunedin is one of many coastal settings facing multiple challenges from climate change and sea level rise. The Parliamentary Commissioner for the Environment has identified South Dunedin as one of the most climate change-exposed communities in the country. Already facing risk of storm-related surface flooding, parts of the city were expected to become even more vulnerable as groundwater levels rise and reduce the dry ground available to absorb rainfall.

The study is a joint project involving GNS Science, Otago Regional Council, Dunedin City Council, and University of Otago. Findings were drawn from 12 months of data from 23 boreholes in South Dunedin and Harbourside. Instruments in the boreholes recorded data every 15 minutes on how water beneath the city responded to rainfall, seasonal variation, hillslope runoff, pumping, and the effect of tides.

The data showed there is less water in the subsurface to manage and it is slower moving than previously thought. This means it should be easier to manage and to develop mitigation measures than anticipated. Monitoring will continue to confirm these initial observations before any decisions are made about mitigation measures.

> **"This new research to better understand South Dunedin's groundwater is important as we develop options which will reduce flood risk and respond effectively to climate change."**
> Simon Drew, General Manager Infrastructure Services, Dunedin City Council

The study will contribute to developing mitigation measures for South Dunedin. It was supported by the NZSeaRise programme – funded by MBIE and led by Victoria University of Wellington – and GNS Science's groundwater programme funded by MBIE's Strategic Science Investment Fund.

Top: Scientists used data from 23 boreholes in the low-lying and densely populated South Dunedin area to understand the sensitivity of groundwater to sea level rise and heavy rainfall events. Results will have implications for city engineering and will be a reference point for other low-lying coastal areas.

SNAPSHOT

23
Scientists installed 23 boreholes for monitoring groundwater levels

12 months
They collected data from the boreholes for a year

Instruments in the boreholes recorded data every 15 minutes

Data showed there is less water in the subsurface and it is slower moving than previously thought

ENVIRONMENT AND CLIMATE

Climate change collaboration awarded 2019 PM's Science Prize

GNS Science is proud to be part of the Melting Ice and Rising Seas team that was awarded the Prime Minister's Science Prize this year. The project is a ground-breaking collaboration tackling the link between climate change, Antarctic ice melt, and sea level rise.

The multi-institutional team is led by Victoria University of Wellington (VUW) and includes Nancy Bertler, Richard Levy and Liz Keller of GNS Science, and researchers from VUW and NIWA. Using geological data from past intervals of warm climate, modern glacial observations, and computer models, the team has shown that the West Antarctic Ice Sheet is highly sensitive to rising ocean temperatures, and that large regions of Antarctica's ice sheets will retreat if our carbon dioxide emissions continue to rise such that the global temperature increase exceeds 2 degrees Celsius.

The impact of this melt and resulting sea level rise on Aotearoa New Zealand's coastline will be large, with significant impact on our coastal communities and environments. The team's research also suggests that if our climate system warms beyond 2 degrees, the ice will begin to retreat and cannot be stopped. This will commit the planet to many metres of sea level rise. These results emphasise that our choices right now will have significant consequences, not only for the coming decades but for centuries and millennia.

The Prime Minister's Science Prize is awarded for a "transformative scientific discovery or achievement, which has had a significant economic, health, social, and/or environmental impact on New Zealand". The award reflects not only the world-class scholarship of the team, but also the impact and influence of their work.

The research and expertise of the team is markedly improving Aotearoa New Zealand's ability to manage impacts of sea level rise. Their work is incorporated into our national Coastal Hazards Guidance and is being used by local government, iwi and other stakeholders across Aotearoa New Zealand. The team's contributions are being enhanced through new research conducted under the Antarctic Science Platform, Resilience to Nature's Challenges and Deep South National Science Challenges, and NZ SeaRise Programme.

In the wake of the COVID-19 pandemic, governments around the world are committing to unprecedented stimulus packages. It is critical that potential climate change impacts are considered, and expert advice will be central to ensuring economies put sustainability front and centre as they rebuild. The team's research confirms the consequences of not doing so could be catastrophic for future generations.

The group will invest $400,000 of its prize to fund scholarships in perpetuity for PhD students in Antarctic and climate research.

Top: Climate scientists Richard Levy, Liz Keller, and Nancy Bertler of GNS Science are part of the Melting Ice and Rising Seas team that won the Prime Minister's Science Prize.

SNAPSHOT

Project tackles the link between climate change, Antarctic ice melt, and sea level rise

2°C
if our climate warms beyond 2°C, the ice will begin to retreat and cannot be stopped

$400,000
The group will invest $400,000 of its prize to fund scholarships

ENVIRONMENT AND CLIMATE

Early career scientists, big research challenges

GNS Science is supporting and fostering the next generation of environment and climate scientists to work on the big challenges Aotearoa New Zealand faces.

Post-doctoral research fellows and early career scientists not only bring fresh ideas to GNS Science, but also build our organisation's capability in key areas.

Among them are Katelyn Johnson, Lucas Domingues and Georgia Grant. Their research demonstrates the breadth of environment and climate activities at GNS Science. Katelyn is working on ice core paleoclimatology, Lucas is focusing on carbon cycling with the NIWA-led MBIE funded Endeavour programme CarbonWatch NZ, and Georgia is researching sea level rise and its coastal impacts.

Two of our early career scientists – Dan Lowry and Mario Krapp – are part of the Antarctic Science Platform's new National Modelling Hub, a joint initiative involving GNS Science, NIWA, and Victoria University of Wellington (VUW), which opened in early 2020. Dan is an ice sheet modeller and Mario is a data scientist.

The Hub is hosted within the Antarctic Research Centre at VUW and undertakes cross-disciplinary research to support the MBIE-funded Antarctic Science Platform's research. It builds on long-standing partnerships between the three organisations. It is addressing key questions around predicting the contribution of Antarctic meltwater to sea level rise, changes in ocean uptake of heat and carbon dioxide, changes in atmospheric and ocean circulation, sea ice extent, nutrient fluxes, and ecosystem dynamics and impacts.

EARLY CAREER SCIENTISTS

1. Georgia Grant's PhD research on sea-level variability in response to Antarctic ice sheet growth and retreat during the two-degrees warmer period of the Pliocene (3 million years ago) was published in *Nature* last year. She continues this work at GNS Science on lessons learned from warmer-than-present climates of the past as analogues for the future.

2. Lucas Domingues is studying the source and fate of greenhouse gas urban emissions in Aotearoa New Zealand as part of the NIWA-led MBIE-funded Endeavour programme CarbonWatch NZ, which aims to provide valuable information for the country's zero carbon emissions objective. Before joining GNS Science, Lucas performed studies measuring carbon emissions due to land cover change and biomass burning in the Amazon rainforest.

3. Dan Lowry uses numerical ice sheet models to understand ice sheet dynamics and sensitivity to changes in climate. He is working on reconstructing the Antarctic and Greenland ice sheet configurations during past warm periods in Earth's history, and developing projections of future ice sheet contributions to global sea level.

4. Mario Krapp is a data scientist at the National Modelling Hub as part of the Antarctic Science Platform. He uses machine learning and neural networks to make sense of the wealth of re-analysis, marine sediment, and ice core and remote sensing datasets and to derive new insights about Antarctica.

5. Katelyn Johnson works in our ice core research facility analysing the Roosevelt Island Climate Evolution project (RICE) ice core using her expertise in paleoclimatology. She is interested in incorporating the RICE ice core record with a sediment core from offshore Adélie Land in East Antarctica, as well as other paleoclimate archives. Together these records can tell us about ice-ocean-atmosphere interactions over the last 12,000 years.

ENVIRONMENT AND CLIMATE

What lies beneath: gravity and seismic data-gathering on the Ross Ice Shelf

Sometimes to look forward, you need to look back. Our expertise in measuring gravity and collecting seismic data is helping to pave the way for a major international study of how the Ross Ice Shelf and the West Antarctic Ice Sheet will respond in a warming world. This in turn will lead to better estimates of sea level rise and its likely impact on our coastal communities.

The multi-year research programme will improve the understanding of how Antarctica's ice behaved during past warm periods in Earth's history. Our scientists led an Aotearoa New Zealand team that collected gravity and seismic measurements at an area known as the Siple Coast, on the Eastern side of the Ross Ice Shelf, to help lay the groundwork for several research seasons ahead.

The area is the 'grounding line' of the West Antarctic Ice Sheet, where the ice meets the ocean and starts to float, becoming the Ross Ice Shelf. Scientists see the 'grounding line' as an area of great importance for understanding how ice flows into the ocean and what happens to it once it does.

We took 150 gravity measurements on a 20km x 20km rectangular grid using the GNS Science portable gravity meter. This helps in understanding the nature and thickness of the rocks and sediment beneath the ice. The measurements will indicate the optimum location for future ice and sediment studies for research. This can be determined by the modelling of seismic and gravity data.

In coming seasons, a drilling system developed in Aotearoa New Zealand will collect sediment cores from beneath the ice shelf that will enable scientists to test the climate and ice sheet models that are used to forecast future changes. Modelling has shown that if the West Antarctic Ice Sheet melts, global sea level will rise 4 metres. Levels will rise even more if the larger and more stable East Antarctic Ice Sheet melts.

The aim of this research programme is to find out when and how fast this will happen. Findings will contribute to global climate models and help New Zealanders to mitigate and adapt to future environmental and climate change.

This research is funded by the New Zealand Antarctic Research Institute and the MBIE-funded New Zealand Antarctic Science Platform, and is a collaboration involving Victoria University of Wellington, GNS Science, NIWA, the University of Otago, and the University of Canterbury.

Top: Scientists prepare for a seismic survey on the Ross Ice Shelf.

SNAPSHOT

150
150 gravity measurements taken

20km x 20km
Measurements from a 20km x 20km grid

4 metres
If the West Antarctic ice sheet melts, global sea level will rise 4 metres

The aim of this project is to find out when and how fast this will happen

SCIENCE THEME

ENERGY FUTURES

As 'the Energy Crown Research Institute', GNS Science plays a major role in enabling Aotearoa New Zealand's transition to a low-carbon energy future. Our research aims to increase opportunities to use renewable energy resources, make efficiency gains, and grow the country's energy resource security.

UNLOCKING THE POTENTIAL OF GREEN HYDROGEN

As Aotearoa New Zealand looks for new fuels and technologies to enable the transition to a low-emission energy system, hydrogen is fast emerging as one of the potential solutions. Our Materials Science team is playing a key role in this transition by applying its world-leading capabilities to help make the hydrogen production process more efficient and less expensive.

> **"First Gas believes GNS Science's hydrogen objectives align with a key research need for New Zealand as we seek to decarbonise this country's energy mix. It also addresses some important questions for our company as we consider the options for reducing emissions in our own operations and providing an energy delivery service based on renewable fuels."**
> Iwan Bridge, Chief Operating Officer, First Gas Limited, New Plymouth

Hydrogen improves the resilience of the energy system as it offers a convenient pathway to store excess energy from renewables and use it during peak power demand. When it is produced by using a renewably-generated electric current to split water into its component elements of hydrogen and oxygen, it becomes a zero-emission fuel known as green hydrogen.

With many countries hungry for low-emission energy solutions, green hydrogen is a compelling option. It can be used to power our heavy vehicle fleet, or as an export commodity. As well as its potential as a fuel, it could also help to create new industries and jobs.

However, there are a number of daunting technological and economic barriers that work against the large-scale uptake of green hydrogen. Current catalyst materials use precious metals, such as platinum, that are scarce, expensive and difficult to deposit onto the ion exchange membranes required to separate hydrogen from oxygen.

Along with our research collaborators in Aotearoa New Zealand and internationally including Boston University in the USA, the University of Würzburg in Germany, and the University of Newcastle in Australia, GNS Science is working on low-cost alternatives using ruthenium iridium oxide, tungsten carbide, and bismuth vanadate. The aim is to develop new materials that can replace platinum. This world-leading approach represents radical technological change.

Our specialists are also turning their attention to whether lower-purity water, such as waste or sea water, can be used for electrolysis – thus reducing the pressure on clean freshwater resources.

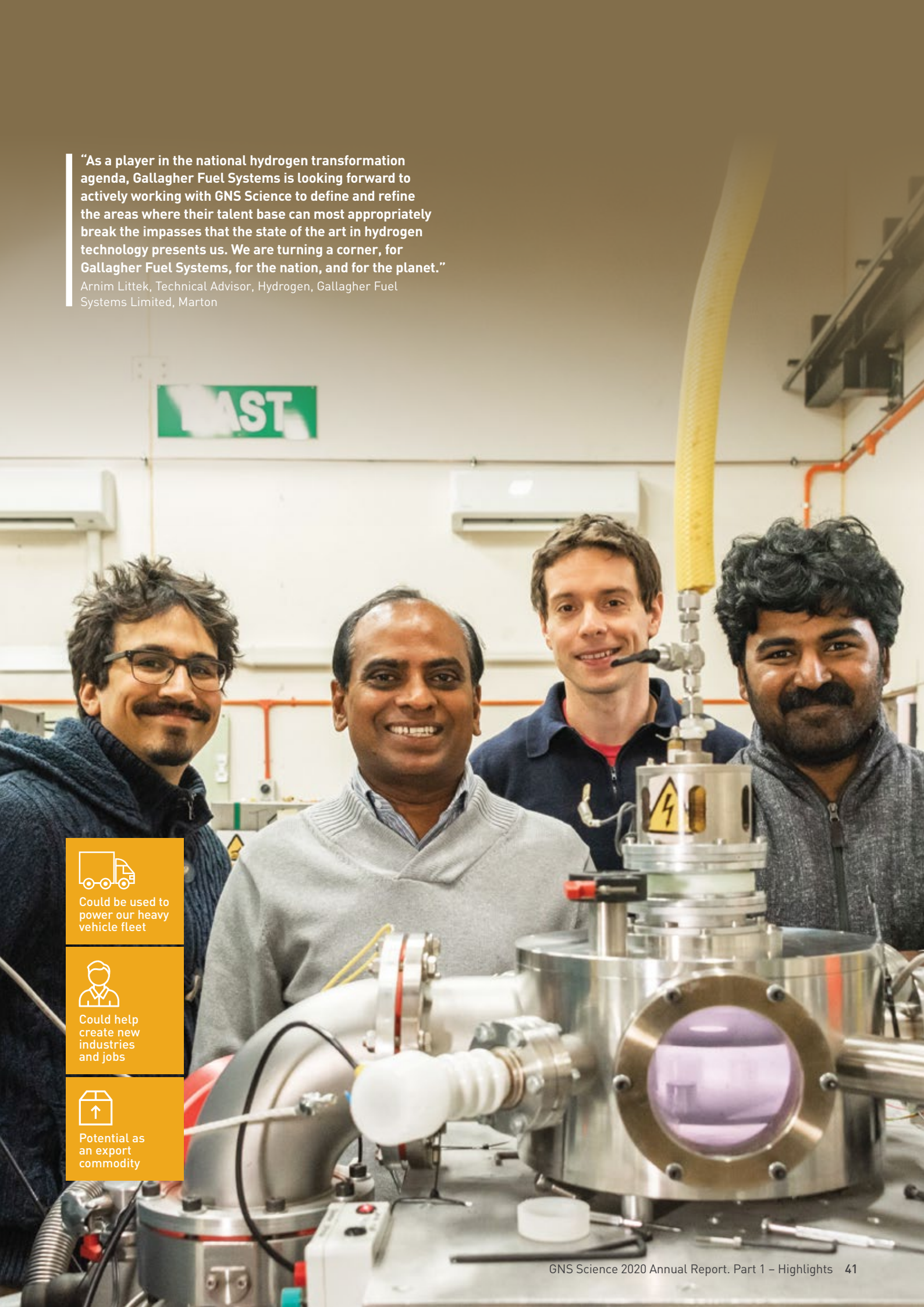
Developing processes and methods for new, high-performing materials is not enough however, as we also need to ensure that these methods can be used at large scale. Based on designs developed in this research project, we are currently building a prototype that will apply catalytic materials onto membranes in a single step at large scales – square metres, as opposed to square centimetres.

To support our research on catalytic materials for hydrogen production, we have commissioned new equipment including a performance measurement system. This is helping us in evaluating our materials in relevant application conditions. We are working closely with industry players such as First Gas, Ballance Agri-Nutrients, Hiringa Energy and Gallagher Fuel Systems, who are keen to help shape the way our research evolves to ensure results are of maximum value to end-users.

We want our research initiatives to inform and improve Aotearoa New Zealand's policies and plans for energy and environmental management, resulting in sustainable economic growth from our energy, land and water resources. This will enable us to fulfil our international commitments with regard to greenhouse gas reduction and contribute to worldwide efforts to decarbonise.

Right: Scientists working on the green hydrogen project at GNS Science from left, Jérôme Leveneur, John Kennedy, Vedran Jovic, and Prasanth Gupta.

"As a player in the national hydrogen transformation agenda, Gallagher Fuel Systems is looking forward to actively working with GNS Science to define and refine the areas where their talent base can most appropriately break the impasses that the state of the art in hydrogen technology presents us. We are turning a corner, for Gallagher Fuel Systems, for the nation, and for the planet."
Arnim Littek, Technical Advisor, Hydrogen, Gallagher Fuel Systems Limited, Marton



Could be used to power our heavy vehicle fleet

Could help create new industries and jobs

Potential as an export commodity

ENERGY FUTURES

Deep geothermal – our clean energy future

We are working with international and New Zealand research and end-user collaborators to significantly increase the amount of energy produced from deeper and hotter geothermal resources in Aotearoa New Zealand. Scientists consider these resources have the potential to play a major role in the transformation of our energy sector.

These resources could be an important contributor to achieving the Government's goal of net zero carbon emissions by 2050. This work will open the way for investment opportunities and new employment, especially in industrial-scale use of energy.

Supported through MBIE's Endeavour Fund, the project is aiming to find underground energy sources that are more than 100 degrees Celsius hotter than currently used in Aotearoa New Zealand. A particular focus in the project is the Taupō Volcanic Zone – the area between Lake Taupō and Whakatāne – and for resources favourable for the development and study of the distinct chemical characteristics of these underground environments.

At present, conventional geothermal wells are drilled to a maximum depth of about 3.5km. However, by drilling beyond this, possibly to 6km, scientists believe more energy will be available at the surface for the same amount of geothermal fluid extracted. The extreme physical and chemical conditions at the deeper depths make it a challenging undertaking.

The project is aiming to identify the best areas for exploratory drilling. It is also exploring the potential for re-injecting carbon dioxide produced as a result, to enable emissions-free 'deep heat' energy.

Laboratory simulations will be used to see how these very hot fluids react with rock, and how their use will affect deep reservoirs and neighbouring shallower reservoirs.

> **"Advancing the technology necessary for development of geothermal resources is a key focus area for Contact. We anticipate the GNS Science-led research programmes such as *Geothermal: The next generation* will provide important insights to ensure sustainable use of geothermal resources for power generation in New Zealand."**
>
> Mike Dunstall, General Manager, Geothermal Resources and Development, Contact Energy

Alongside this work, our experts will evaluate how these deep resources might best be managed under legislative and planning frameworks. The project team is planning significant consultation and engagement with Māori, central and local government, and industry as the project develops.

Deep or very hot geothermal initiatives are also underway in several countries – notably Japan, Italy, Iceland, Mexico, and the United States. However, no-one has successfully managed to harness the very hot geothermal resources from these depths yet.

Deep geothermal generation will only go ahead in Aotearoa New Zealand when there is confidence that it can be done safely, sustainably, and economically. There is more information at: www.geothermalnextgeneration.com

Top: Mercury Energy's Ngatamariki Geothermal Power Plant, northeast of Taupō.

SNAPSHOT

We are working with international and Aotearoa New Zealand teams

A particular focus in the project is the Taupō volcanic zone

3.5km
Conventional geothermal wells are drilled to a max depth of about 3.5km

4km
Scientists believe that there is more energy to be found by drilling beyond 4km

Nobody has successfully managed to harness these very hot geothermal resources yet

ENERGY FUTURES

Geothermal energy in the Pacific Ring of Fire

GNS Science is continuing to expand its sphere of influence in Asia, as Pacific Ring of Fire countries develop their geothermal energy production.

Growing our presence in this region is a strategic priority for GNS Science, with strong market demand. GNS Science is recognised as a leader in geothermal research, and our expertise is in demand from these countries looking to begin or ramp up geothermal energy production.

Japan. Our relationship with Japan spans many years. GNS Science is helping Japan increase geothermal energy production and achieve its target of 1500MW by 2030. Our recent projects in Japan include:

- strategic relationships with government agencies and research organisations
- consultancy work with government and industry, including prospecting studies
- conducting resource reviews of geothermal power developments
- building a tool to visualise geothermal exploration data
- corrosion experiments testing the impact of low pH and high temperature geothermal fluids on metals.

Philippines. We have been assisting geothermal development companies in the Philippines for 10 years, undertaking two or three major projects each year. Our focus in recent years has been assisting clients with reservoir modelling studies for field production optimisation.

Taiwan. Our involvement with Taiwan is into its fifth year. As the country begins geothermal production, we are directly supporting the Taiwan government to understand its geothermal potential. GNS Science has been tasked to undertake a resource assessment of the Tatun Geothermal System, assessing its capacity and helping the country meet its target of generating 200MW from geothermal resources by 2025.

Celebrating Matariki, the Māori New Year, with Taiwan's Council of Indigenous Peoples in 2019 was an opportunity to strengthen indigenous relationships between the two countries. Aotearoa New Zealand's experience in aligning iwi aspirations for geothermal activities with commercial businesses can assist indigenous Taiwanese local communities to consider a range of initiatives for future geothermal research and development.

Indonesia. The geothermal market in Indonesia is booming. Previously, GNS Science has been engaged in passing on knowledge through training. Currently, we are providing expertise in laboratory analytics and experimental geochemistry to help accelerate the capacity for power generation in Indonesia.

The support we receive from NZTE and MFAT is pivotal for our work in the Asia/Pacific region, as they are our 'eyes and ears on the ground', particularly with COVID-19 curtailing travel to the region.

Top: GNS Science ran geothermal geology training with Japan Oil, Gas and Metals National Corporation (JOGMEC) in Aotearoa New Zealand in February 2020.

SNAPSHOT

2030
GNS Science is helping Japan achieve its target of 1500MW by 2030

10 years
We have been assisting geothermal development companies in the Philippines for 10 years

5 years
Our involvement with Taiwan is into its fifth year

ENERGY FUTURES

End-to-end support for the geothermal energy sector

Our geothermal team played an important role in helping Contact Energy assess the feasibility of the Tauhara geothermal field for its proposed new power station. We provided drilling support and geological analysis of appraisal wells to help Contact's investment decision for its development known as Tauhara II.

Our team provided on-call specialist geological advice for each appraisal well as it progressed, and worked with Contact to develop an improved 3D visualisation model to give a better understanding of the Tauhara geothermal resource. Our broad suite of specialist services is based on 60 years of experience and plays a vital role in the geothermal energy industry in the central North Island and internationally.

Results of the appraisal campaign have confirmed that Tauhara is a world-class and globally significant resource and Contact has named Sumitomo Corp to build its $600 million power station.

We also apply our expertise to environmental and cultural issues associated with geothermal development. We are currently working with Tāhorakuri A1 Section 30 Trust to help understand damage to the land around the Ohaaki geothermal field from historic land use. We are also investigating options to revive land that has subsided. The Trust wants to reconnect its community with the land and unlock its value, while ensuring its restoration.

In a two-year MBIE-funded project, we are working with the Trust to jointly develop a customised model that combines geoscience with mātauranga-a-hapū and includes collaboration with the geothermal field operator.

In partnership with the Trust, we have held focus groups and collected oral histories and historic photos as a valuable resource. We have also collated geology and groundwater flow studies and land deformation measurements.

In the coming year, we will combine these two knowledge sets to explore options for development of the A130 block. The project aims to inform the development of a cultural and economic plan for the Trust's land, while preserving and possibly restoring their wāhi tapu and taonga. Our aim is that this model will be a suitable template for other iwi and geothermal fields.

Top: We provide specialist scientific support and services to geothermal energy operators in the central North Island, including Contact Energy's Wairakei Geothermal Power Station (above).

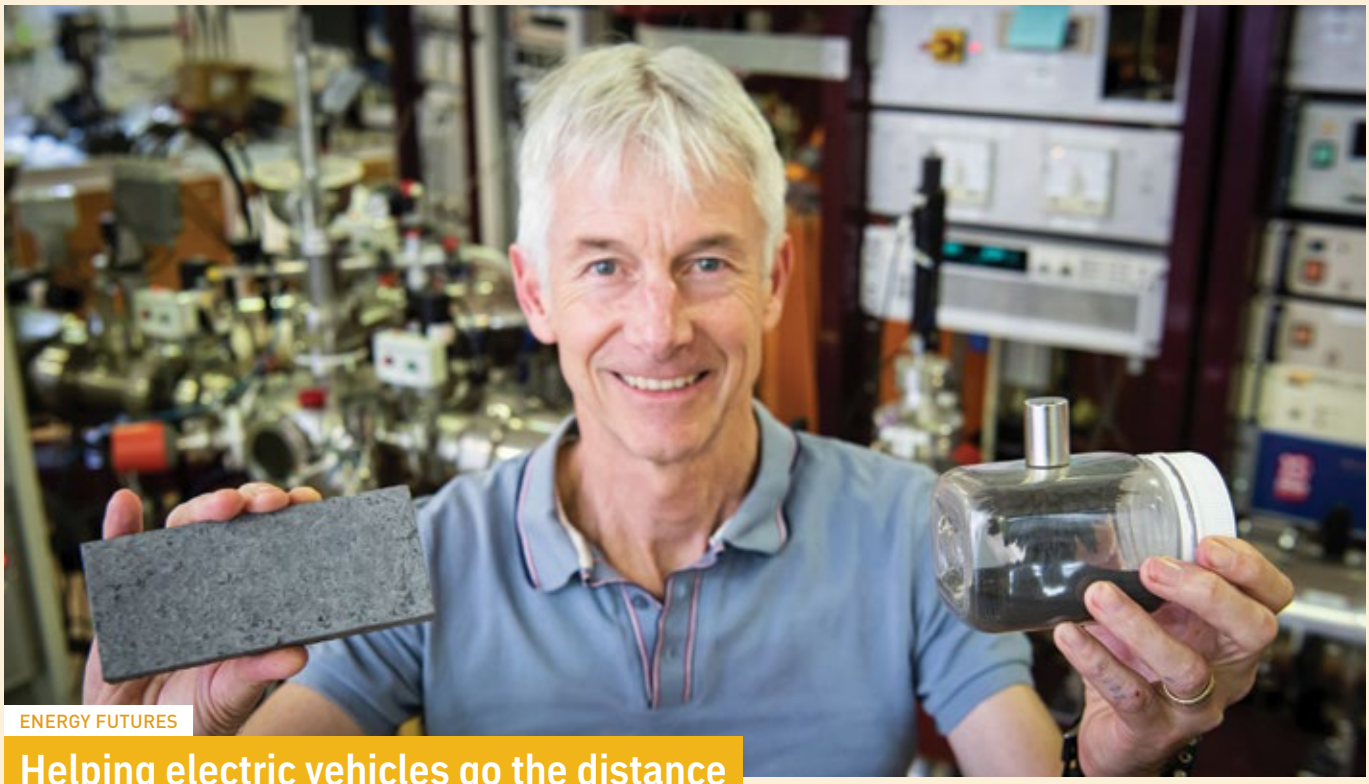
SNAPSHOT

Our team provided on-call specialist geological advice

We worked with Contact to develop an improved 3D sub-surface visualisation model

$600 million
$600 million power station to be built which will be crucial for NZ's low-carbon future

We have held focus groups and collected photos and oral histories as a valuable resource



ENERGY FUTURES

Helping electric vehicles go the distance

Our Materials Science team is part of an initiative aiming to develop a tough composite material that can be used in roads for charging moving electric vehicles (EVs). The new charging system will enable vehicles to charge their batteries from the road itself when they are parked, stopped at the lights or moving along a special charging lane. It would enable EVs to increase their range and boost their uptake, thus helping to facilitate a low-carbon economy without compromising individual mobility.

In-road charging is seen as a convenient and efficient way of charging EVs, but current inductive charging methods use ferrite materials which are very brittle and unsuited for use in roads. We are part of a University of Auckland-led consortium that is working to develop inductive charging systems that can operate in a demanding roadway environment.

Successfully getting a buried roadway material to transfer enough charge to an EV passing overhead without being damaged is challenging science. Along with research partners Robinson Research Institute and Victoria University of Wellington, we are developing and testing a novel soft magnetic composite material that will be both an efficient magnetic inductor and robust enough to last the distance in roads. This involves finding the best combination of magnetic compounds and binders to produce a material that is affordable and has optimum mechanical, thermal, and magnetic properties.

In the near future, several prototype roadway charging materials will be evaluated on purpose-built facilities in Auckland and on a mile-long track in the US. Aotearoa New Zealand is at the forefront of this new technology internationally, and its successful development could have significant economic, as well as environmental, benefits.

> **"The robust magnetic materials that GNS Science and Robinson Research Institute are helping to develop have the potential to revolutionise many applications, including wireless charging, wherever ferrites that are difficult to protect from stress failure, are required to operate in harsh environments."**
>
> Professor Grant Covic, Power Electronics & Inductive Power Transfer, The University of Auckland

The project is funded by MBIE's Endeavour Fund and implementation partners include Vector, Downer, NZTA, Ministry of Transport, and Auckland Transport.

Top: Materials scientist Bill Trompetter with a prototype piece of magnetically inductive roadway material and a jar of magnetite.

SNAPSHOT

New charging system will enable vehicles to charge while driving

New material produced needs to have optimum mechanical, thermal, and magnetic properties

Several prototypes will be evaluated in Auckland and in the US

Aotearoa New Zealand is at the forefront of this new technology

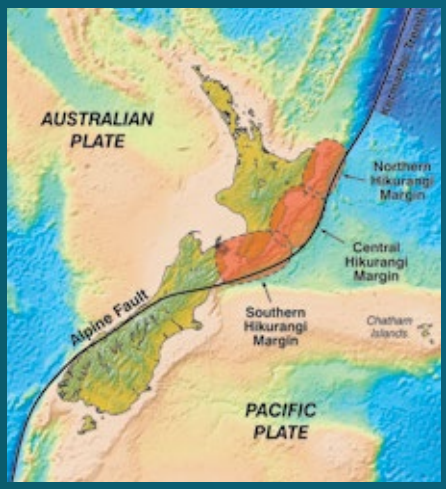
SCIENCE THEME

LAND AND MARINE GEOSCIENCE

Our research is addressing fundamental questions about the composition and architecture of the continent Te Riu-a-Māui / Zealandia and the geological processes that have shaped it. The geoscience data we collect contributes to improved resilience to geohazards, managing natural resources sustainably, and adapting to a changing climate.

UNDERSTANDING A 'SLEEPING GIANT': RESEARCH ON THE HIKURANGI SUBDUCTION ZONE

High-impact research into the past and present behaviour of Aotearoa New Zealand's largest and most active fault – the Hikurangi subduction zone – is producing invaluable information. The aim: to provide more reliable risk and hazard forecasts and drive better community preparedness.



Right: Gisborne school students on a two-day field trip learning about the Hikurangi subduction zone and the hazards it poses to the region's communities.

The Hikurangi subduction zone is where the Pacific tectonic plate dives beneath the east coast of the North Island. A rupture can produce large earthquakes and tsunamis, and a significant event could strongly impact our largest population centres including Auckland, Wellington and Christchurch.

Since 2016, GNS Science has been leading several onshore and offshore projects investigating the behaviour of the Hikurangi subduction zone, many as part of a five-year MBIE-funded Endeavour programme. It is advancing our knowledge about the earthquake potential of the plate boundary and the physical processes behind it.

Our collaborations with national and international partners, community engagement, papers published, and significant contributions from early career scientists have all contributed to the impact of our research in this area.

Ultimately, the knowledge from this large GNS Science-led research programme will enable more reliable forecasts of the hazard and risk which the subduction zone poses to Aotearoa New Zealand.

Building public awareness and resilience

As our research on the Hikurangi subduction zone progresses, we share our findings to build awareness of the active fault and resilience to the potential earthquake and tsunami impacts. To do this, we have partnered with East Coast Life at the Boundary (LAB), a programme that brings together scientists, emergency managers and other experts, with communities along the North Island's East Coast.

This year we invested considerable effort in public engagement and education. Our scientists joined with NIWA and East Coast LAB to present talks in 11 communities in the North Island, reaching more than 1100 people.

We continued to contribute to the development of the Hikurangi Response Planning Toolbox, working alongside Civil Defence and Emergency Management groups who are developing response plans for various scenarios including a magnitude 8.9 Hikurangi subduction zone earthquake and tsunami. Our scientists have been involved with school fieldtrips and educational visits to East Coast schools when undertaking fieldwork in the region, which we hope will help to inspire the next generation of scientists.

News media interest in the work has been very high, with more than 150 articles focused on the research since the programme began.

Strong international interest

Our deep partnerships with international research institutions have helped advance this country's reputation as a focal point for the investigation of subduction plate boundary processes. For example, the high-quality research and datasets created by GNS Science have led to Aotearoa New Zealand being one of three global focus sites for subduction zone research under the US National Science Foundation GeoPRISMS programme.

This global interest in our subduction zone has helped attract around $70 million worth of international investment in science focused on trying to understand the Hikurangi subduction zone.

This year, GNS Science embarked on a new project with Japanese collaborators investigating the parallels between subduction zones in north-east Japan and Aotearoa New Zealand. A key aim is to compare and contrast the causes of earthquakes on both subduction zones. This new work will help to shed light on the types of future earthquakes that might be expected from the Hikurangi fault.

In another project, scientists from GNS Science and Tokyo Institute of Technology, in collaboration with Chorus Ltd, used the underground copper wire telephone network to measure small changes in the Earth's natural magnetic and electrical fields at sites across the Gisborne region. The novel measurement technology can be used to better monitor physical changes inside the fault, and improve understanding of the earthquake and tsunami risk to the East Coast.

Growing body of research and capabilities

The activities in the Hikurangi programme build on knowledge developed from decades of previous research by GNS Science. We are expanding into frontier areas of research for Aotearoa New Zealand including scientific ocean drilling, seafloor geodesy, and using offshore sediment cores to reveal prehistoric subduction earthquakes. More than a dozen early career scientists and students are being trained in skills such as undersea earthquake monitoring techniques, imaging the subduction zone, and using sediment cores to investigate past earthquakes. This will enhance our country's scientific capability base.

In the past year, more than 20 papers have been published in international journals, bringing total publications to more than 40 for the project to date. Ultimately, the research from this programme will feed into initiatives such as Aotearoa New Zealand's National Seismic Hazard Model, and has developed new capability to enable monitoring of our active faults.

Our collaborators

The Hikurangi subduction zone programme is a multi-disciplinary collaboration between GNS Science, NIWA, Victoria University of Wellington, Canterbury University, Otago University, the University of Auckland, East Coast Life at the Boundary (LAB), and iwi/taiwhenua partners. In addition, there is an extensive network of international collaborators in the United States, Japan, the United Kingdom and Europe.

Research has galvanised action

"This research programme, to better understand Hikurangi subduction earthquakes and slip behaviour, has put a spotlight for the Hawke's Bay Civil Defence Emergency Management Group on the sleeping giant just off our shore.

While recognised previously, it is fair to say the Hikurangi subduction zone has been poorly understood and underestimated. Yet this research has clearly established it is potentially the largest source of earthquake and tsunami hazard in New Zealand, which poses a significant threat, being capable of producing a catastrophic disaster for the country, similar to the 2011 Tōhoku Japan event.

Therefore, the work gathering geological and historical evidence of large Hikurangi earthquakes, detecting offshore earthquakes, and better understanding slow slip events to reveal New Zealand's offshore plate tectonic movements for the first time, is hugely significant. GNS Science is to be commended for this work.

The importance of this research is immense. It has galvanised action across civil defence and emergency management groups along the east coast, bringing emergency managers and scientists together to better understand the information needed and the key interdependencies to plan for something our communities have never experienced.

This is incredibly beneficial, as understanding this risk enables our communities to identify potential consequences ahead of time. This allows us to better anticipate what might happen in the future, to help minimise losses and, we hope, ultimately it will save lives."

Lisa Pearse
Team Leader, Hazard Reduction, Hawke's Bay Civil Defence Emergency Management Group; and Chair of East Coast Life at the Boundary

LAND AND MARINE GEOSCIENCE

A wikipedia of Antarctic geology: a world-first digital database

Antarctica's environment will remain highly vulnerable as the global climate warms. Studying the continent's geology is crucial for understanding how the continent has been affected by climate change in the past and how it may react to potential future changes.

GNS Science has led an international project to produce a world-first digital database of Antarctica's geology that will help studies of climate change and glacier dynamics.

> **"Judging by the 350-plus downloads during its first year of availability, GeoMAP is a timely, strategic asset for active research conducted by Antarctic ecologists, biologists, geophysicists, and geologists. Thanks to GNS Science's vision and unique geospatial capabilities, the GeoMAP resource is coming on line at a critical moment when truly interdisciplinary work examines bedrock-icesheet-biosphere interactions."**
>
> Christine Siddoway, Professor of Geology, Colorado College, USA

The Antarctic GeoMAP provides a catalogue of every area of exposed rock on the continent, by type and age. The database describes the geology of every exposed rock on the continent and represents 52,000km^2 of land.

The project encourages continent-wide perspectives and cross-discipline science. Less than one year old, it has already been used to model the flow of meltwater and the resilience of landscapes to changes in climate.

Because there is always new research taking place and there is now an abundance of high-resolution satellite imagery of Antarctica, the database is editable and will be improved over time. The result is a "Wikipedia" of Antarctic geology that conforms to international data standards.

The database signals an important science shift from studying Antarctica's 'deep time' evolutionary geology to the current focus on glacial geology and climate. Rocks play an important role in the complex interaction of land, atmosphere and climate. Having an accurate digital record of the continent's surface geology will be invaluable to researchers in the coming years.

The continent's rock outcrops and cover deposits contain a geological history of the waxing and waning of Antarctica's ice sheets. GeoMAP will foster a better understanding of biological processes.

As well as visiting and assessing hundreds of rock outcrops, the project team scanned and translated up to 500 paper maps into a modern digital source to build the database.

The project was led by GNS Science in collaboration with the Scientific Committee on Antarctic Research, involving 18 collaborators from 12 nations. To learn more visit – https://www.scar.org/science/geomap

Top: The Antarctic GeoMAP, an international initiative in which GNS Science played a leading role, has been used to help describe Antarctic geology in the latest edition of the *Encyclopedia of Geology*.

SNAPSHOT

1st
World-first digital database of Antarctic geology

52,000km²
Represents 52,000km^2 of land

Less than one year old, already used to map the resilience of landscapes to climate change

500
Scanned and translated up to 500 paper maps

GeoMAP will foster a better understanding of biological processes

LAND AND MARINE GEOSCIENCE

Restoring the balance in Hokianga Harbour

Human activity over the past 150 years is thought to have resulted in poor water quality, marine species loss, and damaging siltation in Hokianga Harbour. Local communities want to restore and regenerate it and GNS Science is working with Far North iwi Te Rarawa to build their capacity to manage and restore parts of the harbour.

The collaborative and hands-on project has been co-designed with the iwi to align with their goal of supporting intergenerational development with a focus on environmental, social, economic and cultural wellbeing. The project is funded by MBIE's Vision Mātauranga Capability Fund.

Sediment cores from the harbour are collected and analysed to measure chemical, biological and physical trends covering the past 1000 years. Seeing pre and post-human settlement changes in the cores will help inform the best strategies for regenerating the harbour.

The iwi is using the project to develop remedial actions and management approaches informed by both science and Te Rarawa Mātauranga. Early in the project a hui was held to discuss the goals and logistic plans for the project, community outreach initiatives, and post-project activities – all of which fostered a growing interest in science.

With assistance from iwi representatives, we collected more than 20 sedimentary cores from seven sites in the Hokianga Harbour using a hand percussion coring system. We are analysing the cores at our facilities in Lower Hutt, where they will provide a record extending back hundreds of years.

The project has included interviews with local identities who hold extensive knowledge of land-use changes in and around the harbour in the past century. This included reclamation works and the impacts of roadworks on harbour tributaries. Locals also provided information on changes in fish and shellfish populations. Results will be integrated with analysis of the sediment cores.

All project activities have provided opportunities for knowledge sharing between GNS Science and the iwi. As well as stronger relationships, the project has fostered plans for iwi-focused research projects in the Far North, as well as opening education opportunities in the region.

Top: Joe Prebble of GNS Science and Wendy Henwood of Te Rarawa collecting sediment cores from Hokianga Harbour for analysis.

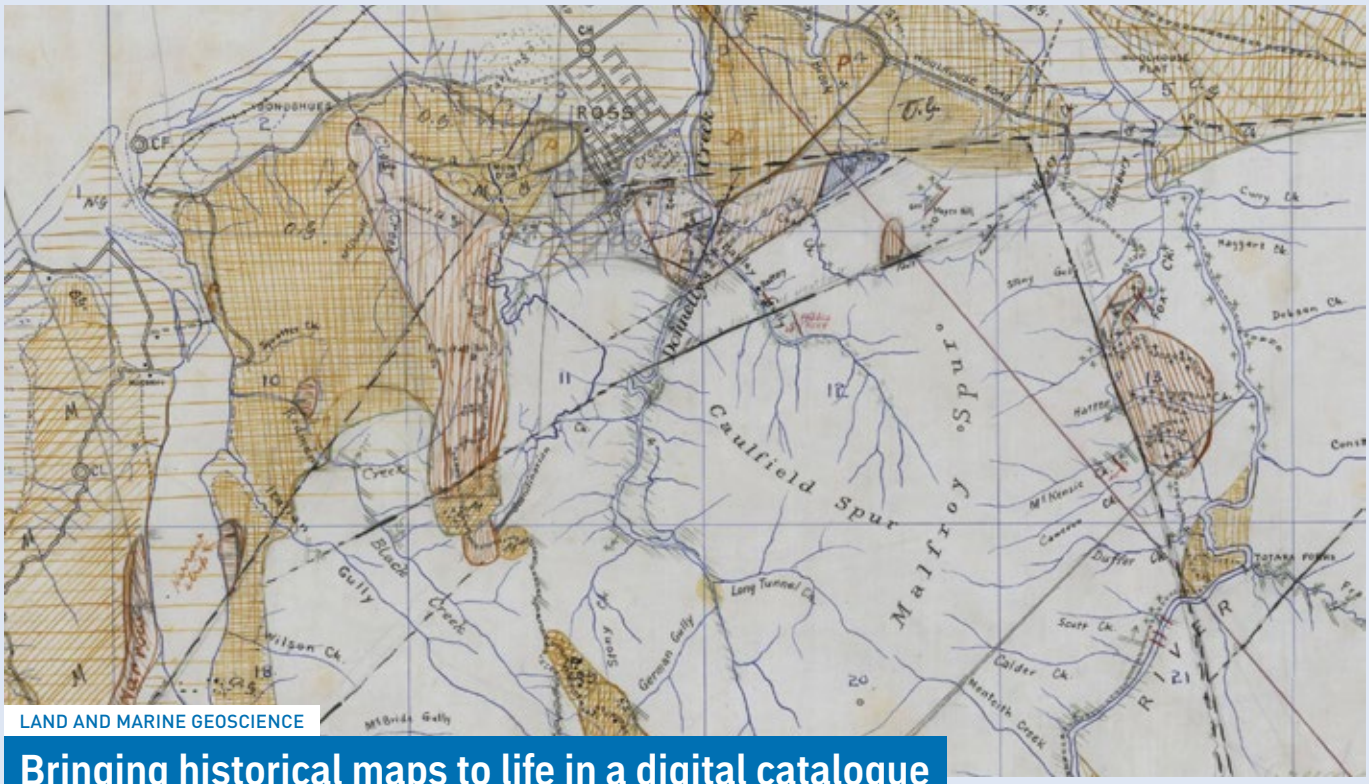
SNAPSHOT

Research plan co-designed and implemented with north Hokianga iwi

20
Sedimentary cores collected in Hokianga Harbour

Cores analysed for pollen, marine algae, sediment type, and ancient DNA

Results to inform development of management plans and new research projects



LAND AND MARINE GEOSCIENCE

Bringing historical maps to life in a digital catalogue

Some of the earliest geological maps of Aotearoa New Zealand can now be viewed online and downloaded thanks to a concerted digitising campaign we began over a decade ago. The archive collection contains 7000 published geological maps and many unpublished compilations.

The earliest maps date back to 1863 compiled by pioneer geologists such as Julius Haast and James Hector. The maps are part of Aotearoa New Zealand's scientific and cultural heritage. The collection covers all parts of Aotearoa New Zealand, at various scales, as well as parts of Antarctica.

Most of the maps are stored in a climate-controlled facility at GNS Science although the oldest, and most precious are kept at Archives New Zealand. Many are beautifully hand drawn and coloured. The collection is part of the Regional Geological Map Archive and Datafile, which is one of our eight Nationally Significant Collections and Databases.

Many of the maps contain extra geological information that did not flow through to publication, including for areas that have been subsequently obscured by construction or vegetation, or removed by excavation.

Some of these maps cover Aotearoa New Zealand's earliest goldfields such as Tuapeka in South Otago. Other mapped areas have been subsequently drowned by hydroelectric dam lakes, such as those along the Waikato and Clutha rivers. The detail in these maps has been used recently for decisions on siting of new water storage dams, archaeological assessments, and mineral exploration.

The high-resolution scans of the geological maps are available from a server linked to GNS Science's Dataset Catalogue – https://data.gns.cri.nz/metadata. Through the catalogue it is possible to view the map images via a browser, download them locally and use them in GIS software applications.

Top: A 1908 map of the Mikonui subdivision, Ross, on the West Coast of the South Island is one of thousands of heritage maps in the GNS Science digital catalogue.

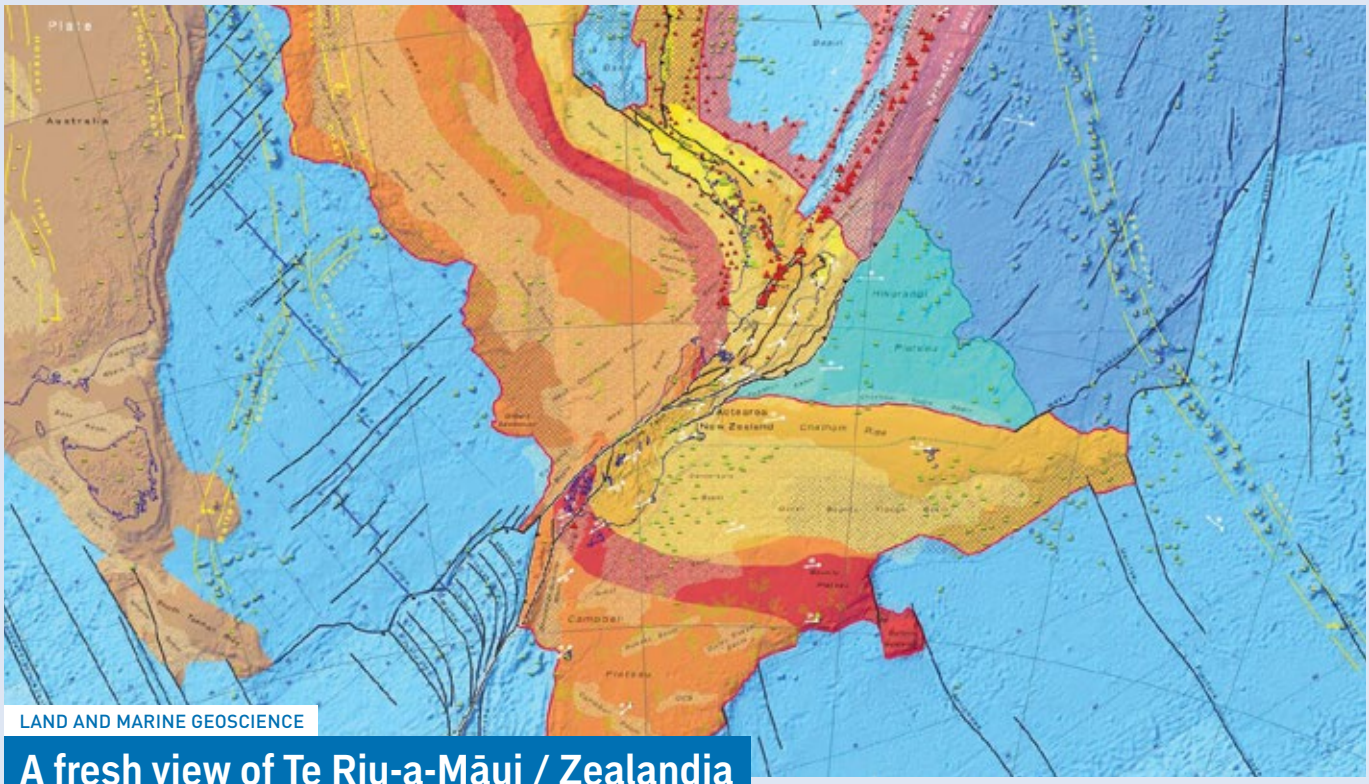
SNAPSHOT

1863
Earliest maps date back to 1863

1 Decade
Digitising campaign began over a decade ago

8
Nationally Significant Collections and Databases held by GNS Science

Maps have recently been used for decisions relating to water, archaeology, and minerals



LAND AND MARINE GEOSCIENCE

A fresh view of Te Riu-a-Māui / Zealandia

New maps and a new website developed by GNS Science give a clearer picture of the amazing forces that shaped Aotearoa New Zealand and the mostly submerged continent beneath our feet.

The maps cover the bathymetry (shape of the ocean floor) and the tectonic origins of the Earth's eighth continent – the 5 million square kilometre Te Riu-a-Māui / Zealandia on which Aotearoa New Zealand sits.

The bathymetric map shows what we would see if we drained the oceans, while the companion tectonic map shows what we would see if we removed all the water and seafloor sediment from the oceans – that is, the continent's solid rock foundations, fault lines and volcanoes. Aimed at geoscientists, educators, and the public, the maps present a detailed and continuous view of Te-Riu-a-Māui / Zealandia from mountain to ocean trench.

The interactive website, E Tūhura – Explore Zealandia (http://data.gns.cri.nz/tez/), includes both the bathymetry and the tectonic maps in digital form, plus a data explorer map. The site was compiled from GNS Science data and augmented by additional information from other organisations. It allows users to add and subtract layers of information from the maps to create, save and share customised views of Te Riu-a-Māui / Zealandia. Users can readily view and interrogate the maps, turn layers on or off, and query features in the layers.

As well as a scientific benchmark, the maps and website are a way of communicating our work to our colleagues, stakeholders, educators and the public. Together, they give us a fresh way to explain and understand the geology of Aotearoa New Zealand and the southwest Pacific area. They are the most complete and up-to-date picture of features such as plate boundaries, volcanoes, and sedimentary basins.

The maps and website were funded through MBIE's Strategic Science Investment Fund and represent the vast knowledge that we have accumulated about Te Riu-a-Māui / Zealandia in recent decades. We will progressively update the website as more research results become available and other organisations make their data publicly available.

The bathymetric map uses the GEBCO 2019 grid, the first output of the Seabed2030 project which is a global initiative to map the ocean floor of the entire world by 2030. The project is a collaboration between The Nippon Foundation in Japan and the General Bathymetric Chart of the Oceans (GEBCO).

Top: The Te-Riu-a-Māui / Zealandia tectonic map shows the continent's bedrock – what we would see if we removed the seawater plus the sediment from the ocean floor.

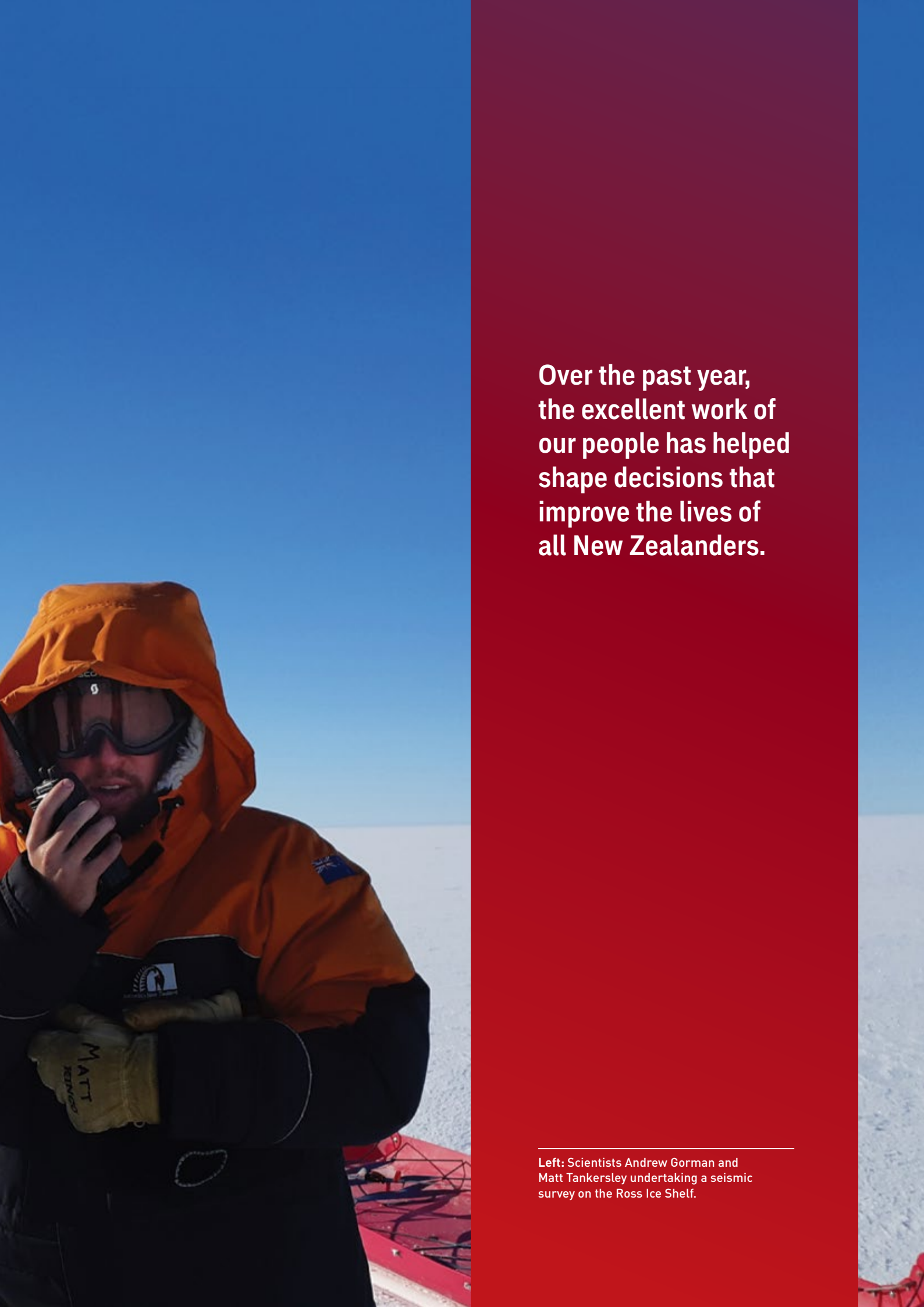
SNAPSHOT

8th continent
Te Riu-a-Māui / Zealandia is the Earth's eight continent

5 million
Te Riu-a-Māui / Zealandia spans 5 million square kilometres

2030
Part of a global initiative to map the entire ocean floor by 2030

OUR ORGANISATION



Over the past year, the excellent work of our people has helped shape decisions that improve the lives of all New Zealanders.

Left: Scientists Andrew Gorman and Matt Tankersley undertaking a seismic survey on the Ross Ice Shelf.

OUR PEOPLE AND CULTURE

People are at the heart of GNS Science's capabilities and success. Our staff are central to our mission of delivering a cleaner, safer and more prosperous Aotearoa New Zealand.

How we attract staff to GNS Science, develop them, inspire and engage them with the organisation's work has a significant impact on our overall success. This year we developed our new People and Culture Strategy to prioritise and guide our work in this area. It was developed collaboratively with leaders across GNS Science and sets out priorities for the next three years which have been incorporated into our business plan. In the first phase, there is a strong emphasis on lifting people leadership capability at all levels within the organisation.

During the year we progressed several initiatives, focusing on developing our people and their capabilities, and reinforcing the supportive culture of GNS Science.

Connected, inspired, empowered

New organisational values for GNS Science have been agreed, which are intended to permeate through all our people-related activities. The three values – **Connected, Inspired, Empowered** – articulate who we are, what matters to us, and how we operate at GNS Science. They centre on 'manaakitanga' – meaning we do the right thing through our interactions with each other and with our clients and stakeholders. Their release was supported by a peer recognition programme and toolkit for people leaders to have conversations with their teams. The values proved their worth through the COVID-19 lockdown helping our staff to look after each other during this difficult period.

1.

Developing effective leaders

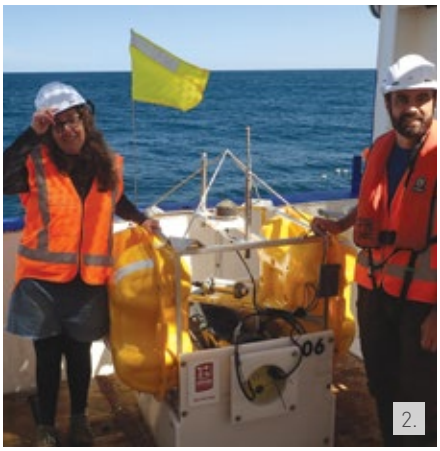
We continue to invest in building capability in leadership at all levels of GNS Science, particularly through the Leadership Development Programme which began in 2019/20. This year there was a focus on coaching, with the aim of embedding a coaching culture within the organisation. Coaching workshops were followed by 'leader labs' to reinforce the skills learnt and highlight specific topics. The leadership programme includes content on personal effectiveness, individual career planning and leadership development pathways, building a team, good management practices, and self-care along the way.

The first session of the new Women in Leadership Forum was held in November. The forum's objective is to encourage women leaders within GNS Science to support each other's development. It includes a speaker series and networking events.

Supporting career development

The new Early Career Staff Network aims to engage and connect staff, build strong working relationships, and promote early career interest in GNS Science's long-term strategic planning. During its first year the network held its inaugural AGM, with the executive leadership team joining this event. The network has also hosted well-attended presentations from GNS Science staff, taken part in the Te Pae Kahurangi CRI Review, and developed a 'buddy' system to support new staff and students. More than 80 people across all our sites have joined the group.

The leadership programme includes content on personal effectiveness, individual career planning and leadership development pathways, building a team, good management practices, and self-care along the way.

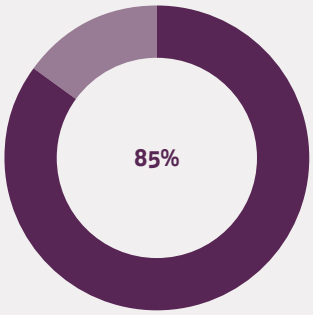


2.

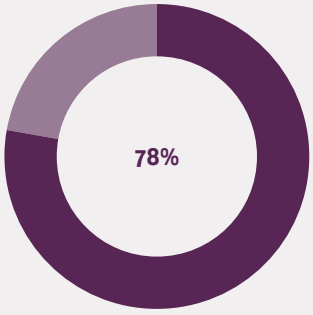
The Career Working Party continues to work on our Capability and Career Framework which will support and enable development across all roles and job families. The framework is scheduled for release this year.

1. Sampling the Mt Ruapehu Crater Lake – Te Wai ā-moe, as part of the regular monitoring of the volcano.
2. Scientists Laura Wallace and Neville Palmer with a seafloor pressure sensor used for measuring small vertical movements of the seafloor at the Hikurangi subduction zone.

1.



Participation in full survey



Participation in pulse survey

Taking stock

Two staff engagement surveys were run during the year – a full survey in September 2019 and a pulse survey in late April 2020 during the COVID-19 lockdown. Participation rates were high for both surveys, with 85 percent for the full survey and 78 percent for the pulse survey. Both surveys provided valuable insights into areas we can focus on to ensure that GNS Science maintains its ability to produce excellent science. Results from the full survey showed 64 percent engagement by staff, up from 62 percent five months earlier, and 55 percent for a sense of common purpose, the same as previously. The pulse survey held during lockdown showed staff were satisfied with GNS Science's support, information and resources during this unprecedented period.

The pulse survey held during lockdown showed staff were satisfied with GNS Science's support, information and resources during this unprecedented period.

A stocktake of our organisation's diversity and inclusion practices provided a valuable baseline for guiding our approach and the development of an action plan. The purpose of the action plan is to foster open dialogue, direct interventions and monitor our approach to diversity and inclusion. Initial actions include planning events to celebrate diversity and raise awareness of the benefits of being an inclusive workplace.

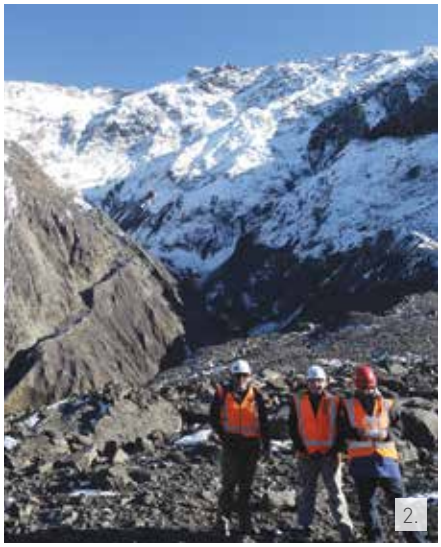
In December 2019 the GNS Science Wellbeing Group was formed, made up of volunteer representatives from across the organisation. The focus is to align to the Five Ways of Wellbeing framework by providing wellbeing initiatives and activities that promote wellbeing at GNS Science.

Equal employment opportunities

GNS Science is made up of people with unique skills, backgrounds and experiences. We are committed to creating and implementing policies, strategies and interventions to make GNS Science an inclusive place where all employees are equal, productive, engaged and satisfied with their jobs.

This year we used the scheduled review of our Equal Employment Opportunities (EEO) policy as an opportunity to acknowledge our commitment to address key diversity and inclusion concepts including equal employment opportunities, equitable pay, flexible work and work/life balance, accessibility, and cultural/community sensitivity and celebration. This includes our obligation, as a Crown Research Institute, to be a good employer in accordance with articles and principles of Te Tiriti O Waitangi. Specifically, we recognise the aims and aspirations of Māori, the employment requirements of Māori, and the need for involvement of Māori as employees of GNS Science.

Our commitment to EEO principles has been applied across the development of our People Strategy and Work Plan. In addition, in 2019 we benchmarked our diversity and inclusion maturity and will track our performance over time.



2.

Building a safety-focused culture

Our goal is to keep our staff safe at work by continually improving our health and safety performance and systems. We want health and safety to be ingrained into the culture of GNS Science. To achieve this, we need good understanding and collaboration between our health and safety team and the people doing the work in our laboratories, on our sites, and in the field. This has been a focus of our work over the past year.

> **The more we understand the risks to health and safety, the more effectively and safely our people can work together, which is our number one priority.**

We have expanded the Health and Safety team with new business partners appointed, so we can build better connections with researchers and support the work being done on the ground. The more we understand the risks to health and safety, the more effectively and safely our people can work together, which is our number one priority.

During the year we introduced a Critical Risk Framework which covers the top nine critical risks for GNS Science. These include field trip work around water, mountains, volcanoes and geothermal activity, use of helicopters, hazardous substance management and driving vehicles. We are focusing our efforts on these risks and their mitigation, with controls put in place, which are regularly verified. The goal is to generate behavioural change around these risks and ultimately keep our people safe at work.

The annual staff engagement survey in September 2019 included questions to better understand staff attitudes and behaviours in relation to health and safety at work. In comparison to the WorkSafe benchmark, we scored reasonably well, with some areas identified for improvement. This included maintenance of machinery and equipment, with a comprehensive analysis subsequently completed of machinery across all sites to ensure it is up to scratch.

3.

Other work which is designed to ensure GNS Science is a safe workplace included improvements in managing hazardous substances and contractors, and centralising and improving emergency response plans for our people in the field. We are also introducing useful technology to help keep our people safe when they are working in remote locations or performing potentially risky tasks. Increasingly we are using drones to view elevated sites, measure features such as landslides from a distance, or take samples such as hot water from geothermal springs. Smarter GPS devices track staff in the field so we know where they are – and they can send emergency alerts and text messages from isolated places.

Training continues to be a focus to ensure our staff are competent in the field and laboratory with activities such as first aid, boat work, driving 4WD vehicles, and handling hazardous substances.

1. Scientists Kate Clark and Jocelyn Turnbull in GNS Science's Rafter Radiocarbon Laboratory.
2. Scientists Chris Massey, Brenda Rosser, and Regine Morgenstern using an unmanned aerial vehicle to survey the Hapuku River landslide dam near Kaikōura.
3. Using infrared technology to measure volcanic gas emissions from Mt Ruapehu's Crater Lake.

VISION MĀTAURANGA

In our work as the Earth science CRI, GNS Science needs enduring and sustainable relationships with tangata whenua – the people of the land. To do this, we needed to capture what it is we do well and establish a clear and consistent approach to our engagement with iwi, hapū, whānau and Māori. We have taken a big step towards our engagement goals this year, with the implementation of our Māori Engagement Strategy.

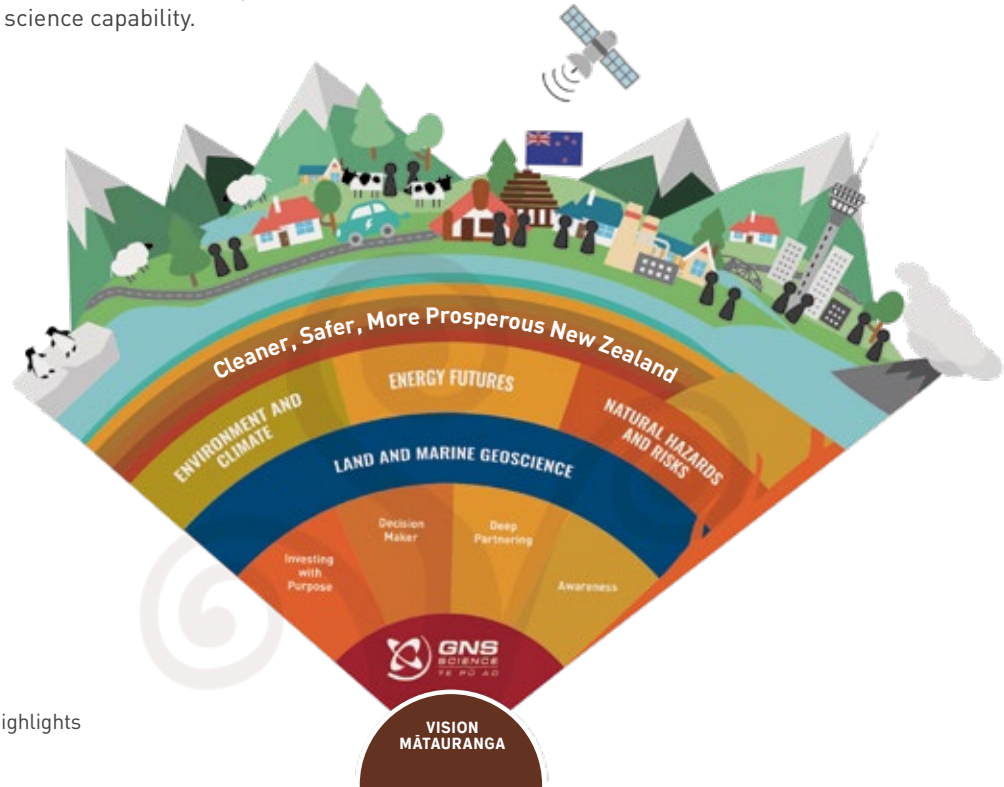
We already have many good working relationships, and we want to build many more. Iwi, hapū, whānau and Māori want to be visible and reflected in our strategic direction and thinking. They want to be involved early so they can participate and contribute fully. And they want relationships to be continuous and unbroken between projects.

There are real benefits for GNS Science, too. From our interaction with iwi/Māori we gain a rich picture of the Earth – by layering our scientific work with iwi/Māori narrative about their relationship with the whenua and te taiao. The Strategy is helping us take a big step towards iwi-led research, where iwi/Māori decide what is studied and what will be done with the results of their research. We will gain a deeper understanding of mātauranga Māori and how it contributes to our work. It will make future projects, partnerships and investment smoother. It will lead to quality research and excellent science. And it will foster rangatahi interest in science, so we can help build Māori science capability.

The Strategy has provided a framework for those putting forward new proposals. It is designed to get us thinking about opportunities for iwi/Māori and who we should be liaising with. For projects that are already underway it provides guidance when needed.

From our interaction with iwi/Māori we gain a rich picture of the earth – by layering our scientific work with iwi/Māori narrative about their relationship with the whenua and te taiao.

It has also led to the development of a Māori Engagement database, so information about all our relationships is current and accessible to staff. As part of our commitment to develop GNS Science's capability and capacity to support Vision Mātauranga, we have started an ongoing Te Reo training programme, being offered at Levels 1 and 2.



We launched the inaugural Ahunuku Māori Summer Scholarship programme and supported Māori students who undertook internship programmes. For these, we invited tertiary students of Māori descent to spend a summer working with our researchers. The two programmes are designed to help build stronger connections between GNS Science and the academic community, increase the talent pool for future recruitment of scientists, and enhance Māori capacity and capability within our organisation. While we have hosted many interns of Māori descent through internship programmes, this is the first time we have developed dedicated programmes providing pastoral support as well as scientific opportunity.

We launched the inaugural Ahunuku Māori Summer Scholarship programme and supported Māori students who undertook internship programmes.

The Ahunuku Māori Summer scholarship programme is run in partnership with Victoria University of Wellington and saw two students work on-site with GNS Science researchers over the summer. In our Māori internship programme, four interns worked at GNS Science as research assistants on projects during the summer break. Through the guidance and support of our researchers, we are providing the opportunity for these students to gain valuable experience. The programmes will be repeated this coming summer.

Top: Scientists and Te Rarawa iwi using sediment coring equipment at Motukaraka, Hokianga Harbour.

IMPROVING OUR DELIVERY

Infrastructure

GNS Science's strategic intent is that our significant data resources, models and associated technologies, as well as our property, equipment and IT infrastructure, support excellent and impactful research for the benefit of Aotearoa New Zealand.

We are working to understand the investment required in our property and infrastructure, beginning with a comprehensive review of the current state of our buildings and other infrastructure, and our needs into the future.

This review will inform the development of a Property Strategy. Several key pieces of work have been completed, including audits to establish the risk baseline and potential of our sites for development, geotechnical reviews, and asbestos audits.

We are also keeping close links with other Crown entities looking to invest in property. The Property Strategy has been delayed by several months due to COVID-19 restrictions and will now be completed by the end of December.

Implementation of the Information Systems Strategic Plan progressed, with highlights being the replacement of our data storage infrastructure, and the roll out of a suite of systems and tools that allowed GNS Science to operate smoothly through the COVID-19 Level 4 restrictions.

1.

Connectivity and innovation

A GNS Science Stakeholder Survey has been initiated this year, replacing a biennial stakeholder survey for all CRIs that has been discontinued. GNS Science aims to deliver excellent, mission-led research, and the survey is a helpful indicator of the relevance of our research and how responsive we are to major stakeholder priorities and needs. This applies across the full science value chain from fundamental to applied research, tools and technologies, and knowledge dissemination.

> **Our new Stakeholder Engagement Programme is progressing well, with the GNS Science Stakeholder Survey informing the development of new engagement principles and approaches.**

This year's survey results show ongoing positive trends in overall stakeholder satisfaction (80 percent satisfaction in 2020), and the highest-ever confidence that GNS Science considers sector priorities in setting its research priorities since stakeholder surveys began in 2012.

We are seeing similar results as in the last survey (2018) for stakeholder confidence that GNS Science can put together the right research teams, and a downward trend in the percentage of stakeholders that have adopted knowledge/technology from the CRI in the past 3 years. These two latter results reflect a general downward CRI sector trend for these two questions.

Our new Stakeholder Engagement Programme is progressing well, with the GNS Science Stakeholder Survey informing the development of new engagement principles and approaches. Programme activity over the past year included stakeholder mapping, establishment of stakeholder 'Communities of Practice' designed to share information with our major stakeholders and lift our responsiveness to their needs, and development of pilot engagement plans. Our engagement with iwi/Māori also now reflects these approaches, as well as working in alignment with the Māori Engagement Strategy.

Improving business processes

With GNS Science moving towards greater investment in more fundamental, technology-led and data-driven research, our investments will also have a higher risk profile overall. To mitigate this, we have put in place greater management oversight of our science themes, and new governance and accountability frameworks. This year, we have initiated a project-based operating model, where our work is delivered through projects and programmes. Our project management specialists are actively involved in 15 of our major projects, and we have developed a project management framework for managing the remainder of our projects and programmes. This will be rolled out in the 2020/21 year.

We made good progress in our resilience, readiness and response programme this year, with particular focus on Geohazard Response and Business Continuity planning. Our capabilities were tested by two major events – the Whakaari eruption and the COVID-19 pandemic, and GNS Science responded successfully to both of those situations.

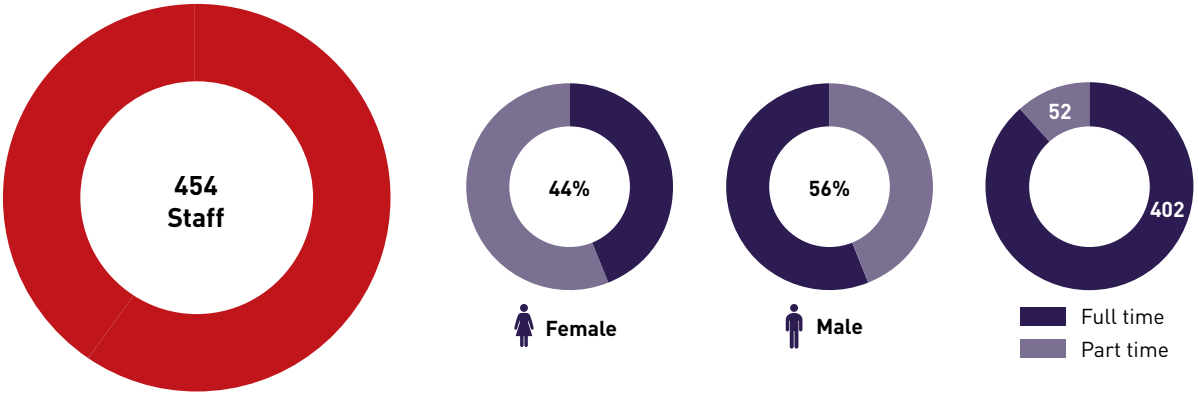
When GNS Science enters Geohazard Response mode, large parts of the organisation must immediately put aside their day-to-day work and begin a high intensity response. Our response plans and structures were reviewed and updated early this year, and were applied in our response to the Whakaari/White Island eruption in December, and for many weeks following the eruption. Our response model and processes will now be refined, to incorporate lessons learned from the eruption.

We also began a review of our Business Continuity planning early this year. Our plans address the loss of key facilities, IT systems and roles, and the COVID-19 pandemic provided the opportunity to put our plans into action. Successful remote-working during the COVID-19 pandemic indicated that we are likely to be resilient against other scenarios that would leave us unable to use our buildings and other facilities. Lessons learned will be incorporated into our plans as they are reviewed and updated.

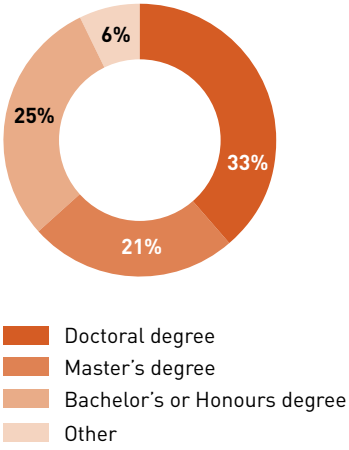
When GNS Science enters Geohazard Response mode, large parts of the organisation must immediately put aside their day-to-day work and begin a high intensity response.

1. Early Career Staff Network members at their inaugural AGM in 2019.
2. Scientists from Aotearoa New Zealand and the United States on the International Ocean Discovery Program ship *JOIDES Resolution* during a voyage to investigate the Hikurangi subduction zone off the North Island's east coast.

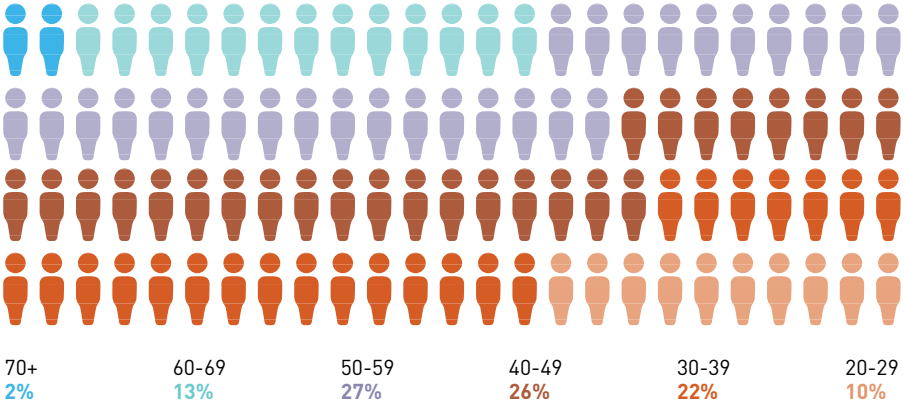
OUR PEOPLE AT A GLANCE



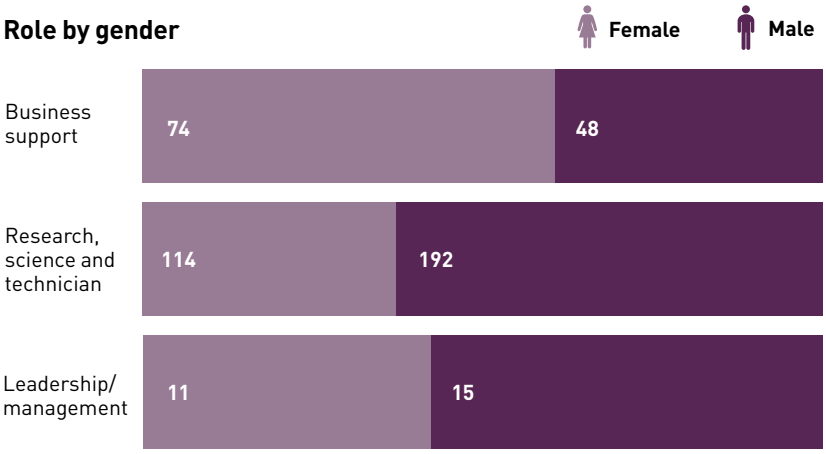
Qualifications



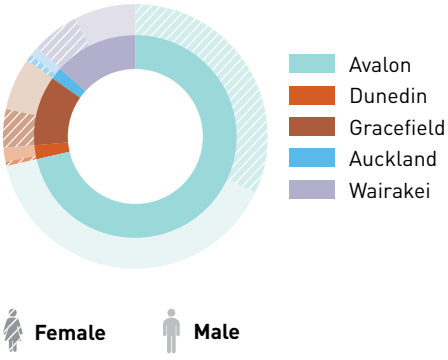
Age



Role by gender

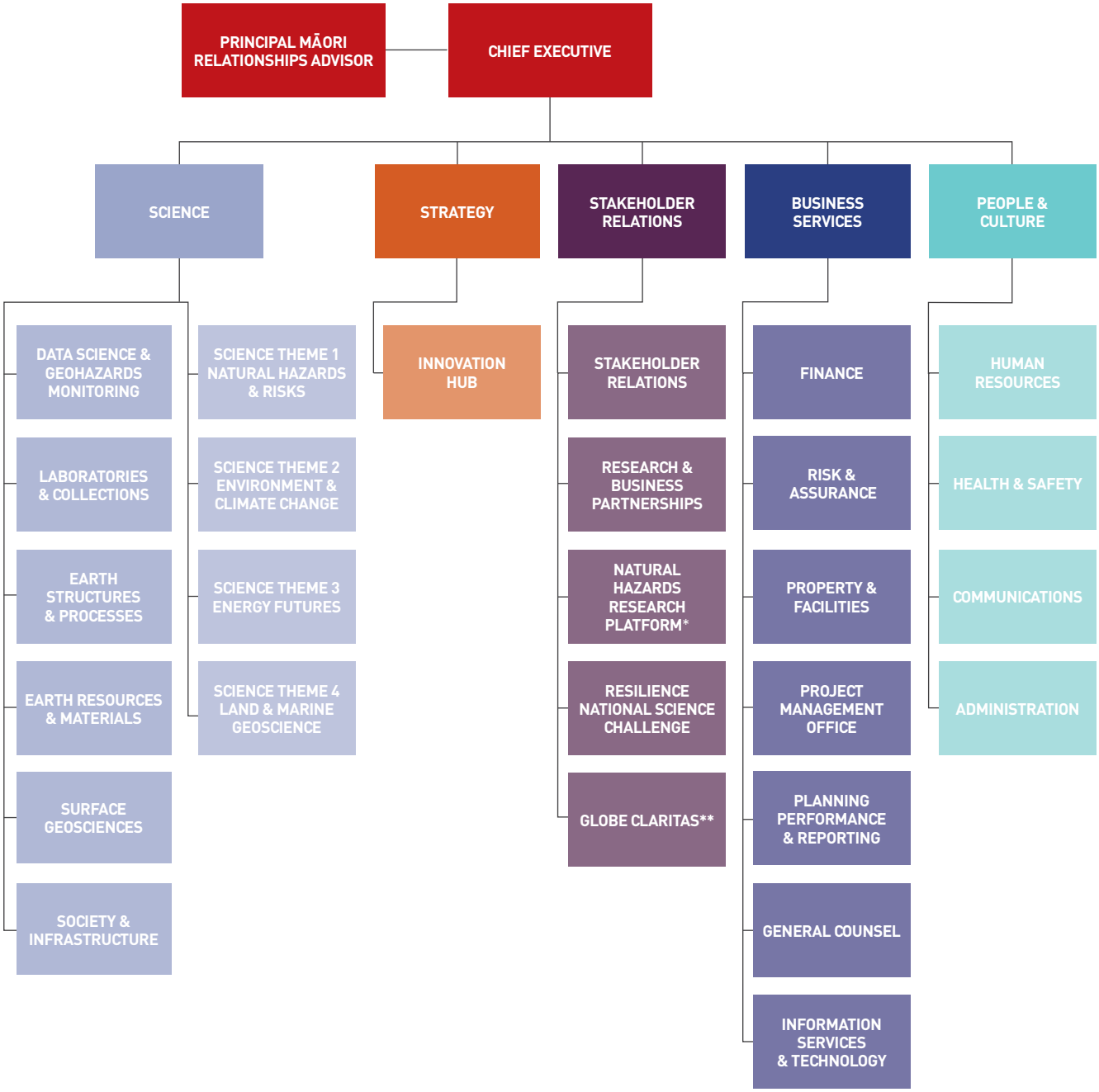


Split of staff by site



OUR ORGANISATION

The staff at GNS Science are invaluable. They are the backbone of the work that gets done across many different sectors within our organisation.



*Our role as host completed 31/10/2019
**Sold to Petrosys NZ Ltd October 2019

OUR BOARD OF DIRECTORS

Left to right: Paul White, Felicity Evans, Sarah Haydon, Dr John Sharpe, Dr Nicola Crauford and Chris Bush.

Dr Nicola Crauford

Chair
BSc (Hons), PhD, FEngNZ, CPEng, FAICD, CFInstD
Wellington
(Appointed 1 July 2015)

Nicki is a professional company director with extensive governance and senior management experience including executive roles in the oil and gas and electricity sectors in Aotearoa New Zealand and the United Kingdom. She is currently a director of Watercare Services Ltd, CentrePort Ltd, Kāinga Ora – Homes and Communities, and Pioneer Energy.

Sarah Haydon

Deputy Chair
BSc, FCA, CMInstD
Auckland
(Appointed 1 July 2014)

Sarah is Chair of The Co-operative Bank Ltd and a Director of Ports of Auckland Ltd. She is a chartered accountant and has worked for BP in the UK and also on international project work, and was CFO at OfficeMax New Zealand. Sarah has an extensive background in planning, finance, general management and organisational development.

Dr John Sharpe

BSc, MSc (Tech), PhD, CMInstD
Hamilton
(Appointed 1 September 2016)

John has held a number of executive leadership and director roles in early-to-mid-stage technology companies in Aotearoa New Zealand and the USA. Trained in the physical sciences, he has spent much of his career developing and commercialising biomedical equipment and other sensor technologies with applications in primary industries, life sciences research, and human health. He has also been involved in state-owned and industry research organisations carrying out science and undertaking business development activities.

Chris Bush

BE (Chem)(Hons), CMInstD
New Plymouth
(Appointed 1 January 2016)

Chris is an experienced oil and gas professional with 30-plus years in both upstream and downstream sectors including roles in Aotearoa New Zealand and overseas. He runs his own consultancy providing strategy and risk management advice to the energy sector and other capital-intensive industries, and has particular expertise in health and safety leadership. He has held a number of director roles and was previously Chair of the Petroleum Exploration and Producers Association (PEPANZ) and of the Be Safe Taranaki Trust.

Paul White

B Arch, MBS
Rawene, Hokianga
(Appointed 14 August 2017)

Paul is from the Ngai Tūpoto hapū of Te Rarawa iwi and has had a 30-year background in Māori development and governance, and wide experience in the public service. He is currently a management and development consultant and professional director and lives in Rawene in the Far North. Over the past 20 years he has served on the boards of Housing New Zealand, Canterbury District Health Board, FITEC, and the Health Sponsorship Council. He is currently a Director of lines company Top Energy Ltd, and Chair of Te Rarawa Farming Ltd, and a member of the governance group of the Māori agri-business stream of the Joint Action Group on Primary Sector Emissions.

Previously he was the Chief Executive of Ngāi Tahu Development Corporation, Regional Director for Te Puni Kōkiri in Tai Tokerau, and Regional Manager for the Housing Corporation in Northland.

Felicity Evans

Graduate of the Australian Institute of Company Directors (GAICD)
Wellington
(Appointed 1 July 2018)

Felicity has more than 25 years of experience in the finance industry, including in retail and commercial banking and human resources. She was formerly the General Manager Talent and Culture for ANZ New Zealand and Pacific. She is a graduate of the Australian Institute of Company Directors, a Chartered member of NZ Institute of Directors, an Associate of the Bankers' Institute of New Zealand, a former Trustee of Diversity Works, and Director of Global Women NZ.

OUR EXECUTIVE TEAM

Ian Simpson

Chief Executive
BSc (Hons), Manchester University
MBA INSEAD, France

Ian joined GNS Science in January 2017. Prior to his appointment he spent seven years as the head of the Earthquake Commission (EQC) where he led the response to the 2010/2011 Canterbury earthquake sequence, one of the world's largest natural disaster insurance events. He brings 30 years' senior leadership experience in public and private sector roles across a range of industries and international locations. After holding corporate finance roles with BP plc and Diageo plc in UK, Australia and Europe, Ian emigrated from Britain in 2006 as GM of Finance at the Accident Compensation Corporation.

Tania Gerrard

Principal Māori Relationships Advisor
Te Whanau a Tāpuhi, Ngāti Porou
BA, University of Otago

Tania joined GNS Science in November 2018 after more than four years with the Ministry for the Environment. Her role at the Ministry was Acting Director of Water, though holding roles specialising in iwi rights and interests, and water rights and interests. Tania's earlier roles included registrar/operations manager at the Waitangi Tribunal and Negotiations Manager with the Office of Treaty Settlements, and Senior Policy Analyst with the Ministry for Primary Industries. At GNS Science her responsibilities include providing strategic advice and guidance to the Executive Leadership Team, and to lead Vision Mātauranga activities across the organisation.

Peter Benfell

General Manager, Science
BE (Hons), The University of Auckland
DipBusAdmin, Victoria University of Wellington

Peter joined GNS Science as General Manager, Science in October 2018. He is responsible for the leadership and management of staff within the Science Group as well as the quality and performance of our research and science. Prior to joining GNS Science, Peter was Chief Executive at the Infrastructure Industry Training Organisation Connexis. He previously worked at GNS Science as Group Manager, Environment and Natural Resources Group between 1998 and 2001, and has had over 30 years' experience in research, science and technology and its successful application. Peter has held senior management roles at the Foundation for Research, Science and Technology, AgResearch, and Opus International.

Rose Macfarlane

General Manager, People and Culture
Post Grad Dip. Management Studies, Massey University
Dip. Business Studies, University of Waikato

Rose was appointed General Manager of the human resources, communications, health and safety and administration departments in July 2018. Prior to taking this role, she was GM, Human Resources at DairyNZ. She has also held positions as Human Resources Manager at Hamilton City Council and the Waikato District Health Board. She has significant experience in managing change, understanding the challenges of differing business environments and dealing with a broad range of organisational culture and people matters.

Justine Daw

General Manager, Stakeholder Relations
PGDip (Pushkin Institute, Moscow), MA (Hons) The University of Auckland, MInstD

Justine joined GNS Science in September 2018 after more than five years at Manaaki Whenua – Landcare Research where she held roles as GM Partnerships and GM Science and Policy. At GNS Science, Justine is responsible for building meaningful relationships with major stakeholders. Having previously worked at the Foundation for Research, Science and Technology and its successor organisations, she has a depth of knowledge of the science system and the science funding environment. Justine has also held senior roles at the Ministry of Foreign Affairs and Trade, NZAID, the NZ Climate Change Office, and the Ministry for the Environment.

Andrew Simpson

General Manager, Business Services
BCom (Otago), C.A.

Andrew Simpson joined GNS Science in July 2019 after 3 years at the University of British Columbia where he held the role of Vice President, Finance and Operations. Andrew is an experienced university leader and advisor, holding previous roles of Chief Operating Officer at Victoria University of Wellington, Vice Principal (Operations & Finance) at Queen's University, Canada, and Chief Operating Officer at Waikato University. At GNS Science, Andrew is responsible for leading a wide range of functions including finance, legal, risk and assurance, ICT, property and facilities, project management office and performance and reporting services.

Left to right: Rose Macfarlane, Ian Simpson, Andrew Simpson, Tania Gerrard, Peter Benfell, Justine Daw and Gary Wilson.

Gary Wilson

General Manager, Strategy & Chief Scientist
BSc (Hons), BMus, PhD, Victoria University of Wellington

Gary joined GNS Science in May 2019. He is responsible for leading GNS Science's science, research and innovation strategies and he contributes to developing the strategic direction and investment for the organisation. He previously held academic positions at the University of Oxford and University of Otago, where he is still an Honorary Professor in Marine Science. He has held the Byrd Fellowship at Ohio State University and the Blaustein Visiting Professorship to Stanford University.

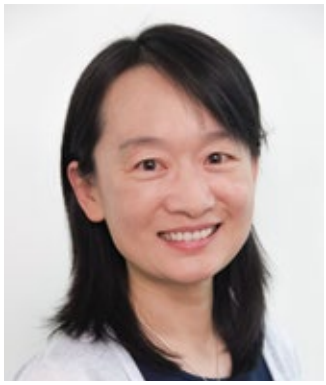
His research interests are in environmental geophysics and marine geology and he still has active research programmes in Antarctica, the Subantarctic and Aotearoa New Zealand. He is currently the Vice-President of the Scientific Committee on Antarctic Research (SCAR), Chair of the Royal Society Te Apārangi Committee on Antarctic Sciences, and a Trustee of the Sir Peter Blake Trust.

STRATEGIC SCIENTIFIC AND USER ADVISORY PANEL

The Panel provides advice on research to the Board. Its purpose is to ensure our science continues to have a focus on excellence and that we are well tuned in to national and international trends and associated opportunities. Panel members have broad experience and insight across all our science themes, and provide strong end-user perspectives.

Dr Chris Pigram

Chris is a geologist with over 40 years of experience and was the Chief Executive Officer of Geoscience Australia between 2010 and 2017. Dr Pigram was made a Member of the Order of Australia in 2019 and was elected a Fellow of the Academy of Technological Sciences and Engineering (ATSE) in 2016. He chairs several Australian committees including the Independent Expert Scientific Committee that advises government on water issues related to large coal mines and coal seam gas developments, the MinEX CRC, and CSIRO's Minerals Resources Advisory Committee. He is also Chair of AuScope Limited, and is a member of the Advisory Panel for CSIRO's Deep Earth Imaging Future Science Platform and was appointed to the Australian Space Agency Advisory Group in 2019.



Dr Ting Wang

Ting is a Senior Lecturer in the Department of Mathematics and Statistics and Associate Dean Research (Division of Sciences) at the University of Otago. Her research field is multidisciplinary, centering on the interface of statistics and geosciences. Her main focus has been on the development of statistical models for geophysical hazards such as earthquakes and volcanic eruptions. Ting has led, managed and participated in national and international collaborative multidisciplinary research projects, including projects funded by EQC, Marsden, MBIE, the Natural Hazards Research Platform and Resilience to Nature's Challenges. She received the Worsley Early Career Research Award from the New Zealand Statistical Association in 2013, and a University of Otago Early Career Award for Distinction in Research in 2017.

Sarah Stuart-Black

Sarah is the Deputy Chief Executive and holds the statutory role of Director Civil Defence Emergency Management in the new National Emergency Management Agency, which was established on 1 December 2019. She was appointed the Executive Director of the Ministry of Civil Defence & Emergency Management in December 2014, having joined the Ministry in 2003. Sarah has had a diverse range of experience in Aotearoa New Zealand, England, Ethiopia, Niue and the Solomon Islands. She was a member of the United Nations Disaster Assessment & Coordination Team for nine years and has represented Aotearoa New Zealand at a variety of international forums, bilateral, regional and global meetings, exercises and forums.

Professor Trevor Ireland

Trevor is leader of the Geochemistry and Cosmochemistry Group at The Australian National University. He specialises in SHRIMP microanalysis and applications in geochronology, stable isotopes, and trace element geochemistry, on terrestrial and extraterrestrial samples. He has worked extensively on geochronology of Aotearoa New Zealand, Antarctica and Australia.

He is currently looking forward to the return of the JAXA Hayabusa2 spacecraft with a sample of asteroid Ryugu on board and is also an investigator on the NASA Osiris-REx mission currently at asteroid Bennu. Trevor is the past President of The Meteoritical Society and is a Fellow of the American Geophysical Union and the Geochemical Society.

Cameron Madgwick

Cameron is the Chief Executive of Gibson Sheat Lawyers. This role builds on his prior executive leadership advocating for the petroleum sector, legal advisory roles in the electricity sector and private practice and governance within the education and justice sectors. Cameron remains active in his community and is the Chair of specialist disability provider Laura Fergusson Wellington.

His experience and connections to the energy sector position him to provide a valuable contribution to the work of the Panel. He has a particular interest in science advocacy and communication.

Dr Lucy Jones

Lucy is the founder of the Dr Lucy Jones Center for Science and Society, with a mission to foster the understanding and application of scientific information in the creation of more resilient communities. She is a Research Associate at the Seismological Laboratory of Caltech and author of *The Big Ones: How Natural Disasters have Shaped Us* (Doubleday, 2018). During her 33 years with the US Geological Survey, she created the first Great ShakeOut drill, now a worldwide event with over 60 million participants in 2018. Lucy also created methodologies for assessing earthquake probability that have been the basis for all earthquake advisories issued by the State of California. Her pioneering science was recognised with the 2015 Samuel J. Heyman Service to America Medal, the Ambassador Award from the American Geophysical Union, the 2016 William Rodgers Distinguished Alumni Award from Brown University, the 2017 Distinguished Lecture Award of the Earthquake Engineering Research Institute, and the 2018 Frank Press Medal from the Seismological Society of America.

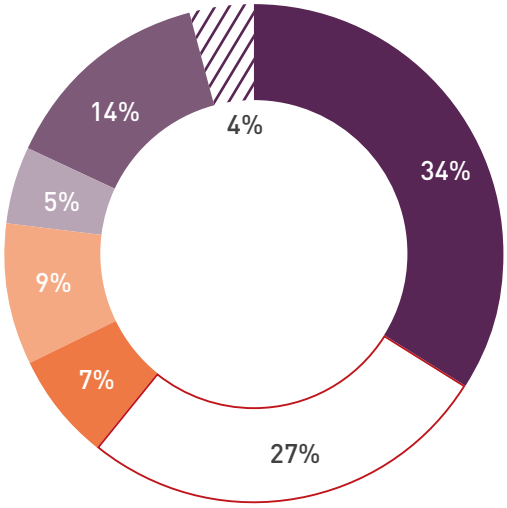
Dean Kimpton

Dean is a specialist consultant providing support to the public and private sector in addressing the unique challenges of growth, infrastructure strategy and delivery. He also holds several current or former governance roles including independent chair for the America's Cup 36th defence advisory board, President of Engineering NZ, QuakeCoRE Joint Venture Board chair, and a director of the Parenting Place charity.

Until May 2019, Dean was Chief Operating Officer for Auckland Council, Australasia's largest local authority. Prior to joining Auckland Council, he was managing director of AECOM NZ. There he developed a successful executive track record in leading buildings and infrastructure design, and delivery in the transport, energy, water and health sectors across Aotearoa New Zealand, Australia and throughout south-east Asia.

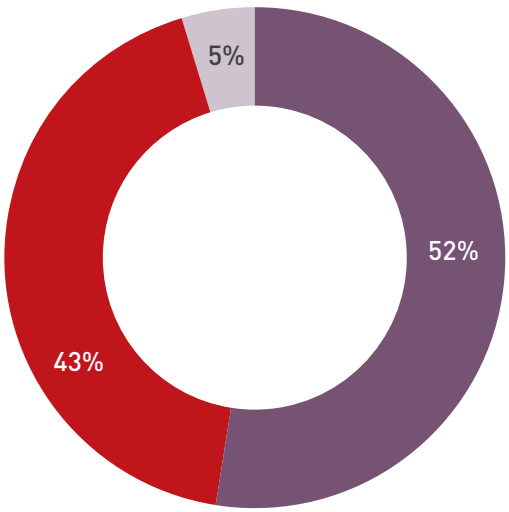
OUR NUMBERS AT A GLANCE

Revenue



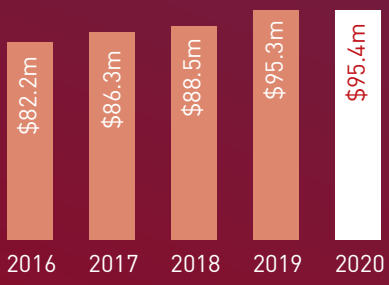
- Strategic Science Investment Fund
- COVID-19 Funding
- Contestable Fund contracts
- Research subcontracts
- Commercial – New Zealand
- Commercial – overseas
- GeoNet services

How we spent our money



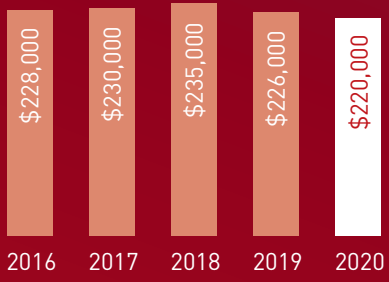
- Employee related expenses
- GeoNet direct expenses
- Other operating expenses

Revenue ($m)



Total assets ($m)

Revenue per FTE ($)



Our $95.4m revenue during 2019-2020 was generated from

68%
Research contracts

14%
Commercial

14%
GeoNet services

4%
Other income

Photograph acknowledgements

Agnes Mazot, GNS Science	P58
Aliki Westrate, Outer Reaches	P49
Angus Howden, GNS Science	P43
Chris Sisarich, NZ Story	P42
Colin McDiarmid	P5, 6, 36, 45, 66, 69
Glenn Evans, GNS Science	P9
Graham Hancox, GNS Science	P7, 21
Hawke's Bay Regional Council	P31
Jenny Black, GNS Science	P37, 54
John Callan, GNS Science	P35
Julian Thomson, GNS Science	P20, 27
Karen Britten, GNS Science	P57
Kate Clark, GNS Science	P26
Kyle Bland, GNS Science	P51, 61
Lloyd Homer, GNS Science	P19
Margaret Low, GNS Science	Inside front cover, P9, 10, 11, 25, 32, 41, 44, 58, 70, 71
Ministry for the Environment	P33
Otago Daily Times	P34
Regine Morgenstern	P59
Richard Johnson, GNS Science	P14
Sarah Searson, NIWA	P24
Tim Fulton, IODP-JRSO	P63
Woolf Photography	P8
Zac Martin, GNS Science	P62

Designed by
Scenario.co.nz

Principal location and registered office

1 Fairway Drive, Lower Hutt 5010,
PO Box 30368, Lower Hutt 5040,
New Zealand
Tel: +64 4 570 1444
Email: avalon@gns.cri.nz

Other locations

National Isotope Centre
30 Gracefield Road, Lower Hutt 5010,
PO Box 31312, Lower Hutt 5040,
New Zealand
Tel: +64 4 570 1444
Email: gracefield@gns.cri.nz

Wairakei Research Centre
114 Karetoto Road, RD4, Taupō
3384, Private Bag 2000, Taupō 3352,
New Zealand
Tel: +64 7 374 8211
Email: wairakei@gns.cri.nz

Dunedin Research Centre
764 Cumberland Street, Private Bag
1930, Dunedin 9054, New Zealand
Tel: +64 3 477 4050
Email: dunedin@gns.cri.nz

Auckland
GridAkl, 12 Madden St, Wynyard Quarter,
Auckland 1010, New Zealand
Tel: +64 4 570 1444
Email: auckland@gns.cri.nz

Our office locations and staffing

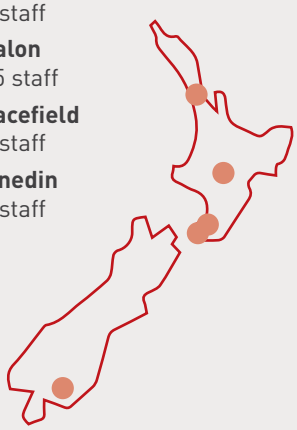
Auckland
7 staff

Wairakei
60 staff

Avalon
325 staff

Gracefield
50 staff

Dunedin
10 staff



Directors

Dr Nicola Crauford
Chair

Sarah Haydon
Deputy Chair

Chris Bush

Felicity Evans

Dr John Sharpe

Paul White

Executive leadership team

Ian Simpson
Chief Executive

Dr Gary Wilson
General Manager,
Strategy & Chief Scientist

Justine Daw
General Manager,
Stakeholder Relations

Peter Benfell
General Manager,
Science

Andrew Simpson
General Manager,
Business Services

Rose Macfarlane
General Manager,
People and Culture

Tania Gerrard
Principal Māori
Relations Advisor

Bankers

ANZ

Auditor

Silvio Bruinsma
Deloitte Limited
On behalf of the Auditor-General

Solicitors

Chapman Tripp

Websites

www.gns.cri.nz
www.geonet.org.nz

Science working for New Zealand

The Crown Research Institutes (CRIs) proudly work, individually and collectively, to create a more prosperous, sustainable and innovative New Zealand

agresearch
āta mātai, mātai whetū

ESR
Science for Communities

GNS SCIENCE
TE PŪ AO

Manaaki Whenua
Landcare Research

NIWA
Taihoro Nukurangi

Plant & Food™ Research
Rangahau Ahumāra Kai

SCION™
FORESTS ▪ PRODUCTS ▪ INNOVATION

www.sciencenewzealand.org

3,600
SMART AND PASSIONATE PEOPLE

50
SITES ACROSS NEW ZEALAND

6,000
SCIENCE PROJECTS EACH YEAR

40
NATIONALLY SIGNIFICANT DATABASES & COLLECTIONS

J008885