

GNS SCIENCE 2019 ANNUAL REPORT



**OUR PEOPLE
OUR SCIENCE
OUR OUTCOMES**



OUR PEOPLE

As a world-leading institute, GNS Science attracts experts from around the globe who are passionate about using science to make a difference. We have more than 20 countries represented on staff. This mix of nationalities contributes to our diverse and vibrant culture.



442

**PEOPLE WORKING
TOGETHER**



OUR IMPACTS

Once again, *Nature* placed us as the top-ranked corporate institution in the world for the quality and number of our publications in Earth and environmental sciences. We take a multidisciplinary approach to our research working closely with our stakeholders and partners to deliver tangible benefits to meet New Zealand's changing needs.



**RELATIONSHIPS
ARE KEY TO OUR SUCCESS**





OUR SCIENCE

For a Cleaner, Safer, More Prosperous New Zealand. GNS Science is committed to producing excellent science that will unlock environmental, social, cultural and economic benefits through our Science Themes:

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



4

**SCIENCE THEMES
FOR A BETTER NZ**





OUR **FUTURE**

Building on our heritage of more than 150 years, we are focused firmly on harnessing our collective efforts for greater impact and benefit for New Zealanders.

We are investing across our four Science Themes to broaden our expertise and to ensure we produce long-lasting benefits for New Zealand and around the world.



24/7
GEOHAZARDS
MONITORING







OUR ACHIEVEMENTS

- 4 From the Chairman and Chief Executive
- 8 Honours and Awards
- 10 About GNS Science

OUR SCIENCE

- 12 Our Science Themes
- 14 Natural Hazards and Risks
- 22 Environment and Climate
- 30 Energy Futures
- 36 Land and Marine Geoscience
- 44 Science Achievements



OUR PEOPLE

- 48 GNS Science 2019 Excellence Award Winners
- 50 Our People and Culture
- 54 Our People at a Glance
- 55 Organisational Structure
- 56 Board of Directors
- 58 Executive Team
- 60 Science Advisory Panel

OUR NUMBERS

- 63 Performance Indicators
- 65 Corporate Governance
- 67 Report of the Directors
- 70 Financial Statements
- 74 Notes to the Consolidated Financial Statements
- 87 Independent Auditor's Report
- 89 Our Year in Numbers
- 90 Directory
- 90 Photo credits

FROM THE CHAIRMAN AND CHIEF EXECUTIVE

At GNS Science we have a strong sense of serving the nation and having a real impact on New Zealanders' lives. We are passionate about our role and the strong track record we have built over many years.

During this past year we continued to deliver globally influential science that contributes to our vision for a Cleaner, Safer, More Prosperous New Zealand for current and future generations.

As part of striving to deliver the most effective and impactful research possible, we completed a major Strategic Review focused on building on our strengths.

The top-to-toe review highlighted the importance of being more outwardly focused, being a valued thought leader, and having a structure that allows rapid adjustment to the changing needs of end-users.

Science is changing, not just in New Zealand but globally too. Increasingly, science is being asked to deliver 'whole solutions' to complex issues. There is greater need for effective interdisciplinary research, and independent science commentary that meets the needs of policy-makers and decision-makers. This brings a sharper focus to science engagement and knowledge-brokering to diverse communities, including Māori.

As a result of the review, we made changes to enable us to be more deliberate and effective in the way we address the changing needs of New Zealand.

In the first phase of change, we reshaped our executive and corporate areas to increase capability and provide more support for our science programmes. Vision Mātauranga has been woven more explicitly into the refreshed science programmes to underline our commitment to developing partnerships with iwi/Māori interests. This first phase was implemented in August 2018.

In the second phase, we focused on the structure of our science divisions, reorganising them into four high-level Science Themes with effect from March 2019. These four themes are now driving our science outcomes. Each theme has four or five research priority areas.

INTRODUCING OUR NEW SCIENCE THEMES

The information presented in this Annual Report covers our work under these new Science Themes:

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

This new structure involves discipline-based groups working in project teams. It allows us to be flexible and pull in individual skills and expertise when

needed. And it means we can respond quickly to new research and commercial opportunities as they arise.

Natural Hazards and Risks are part of New Zealand's — and GNS Science's — DNA. Climate change will increase both the risks and impacts, and our Environment and Climate theme provides insight into the past so we can better manage the future. In turn, our expertise in carbon measurement informs our Energy Futures work — and all of this is underpinned by the Land and Marine Geoscience theme. Science is changing, and GNS Science is changing too.

We also reviewed our programmes funded by the Government's Strategic Science Investment Fund (SSIF). Following internal and external stakeholder consultation, we scoped several new SSIF-funded programmes. These form the backbone of science activity in each of our new Science Themes.

In line with national priorities, we developed a new GNS Science SSIF Energy Futures programme, to enable New Zealand to transition to a lower-carbon economy through next-generation geothermal, new materials and other relevant research. These new programmes will increase GNS's overall investment in discovery science, and leverage our long-standing science collaborations, both in New Zealand and globally.



FINANCIAL RESULT

We posted a net profit after tax of \$445,000 for the year to 30 June 2019. This was a \$1.2 million improvement on the previous year, although \$1.5 million below our budget.

Our revenue continues to grow, up \$6.8 million (8%) to \$95.3 million, which includes significant new funding received from the Ministry of Business, Innovation and Employment for the fit-out and operation of the National Geohazards Monitoring Centre located at our Avalon office. There were also increases in research revenue as we collaborated with other Crown Research Institutes and government agencies, and increases in overseas commercial work particularly geothermal energy, and volcanic and other geohazards throughout the Pacific and Japan.

Operating expenditure (including depreciation and amortisation) increased by \$4.7 million (5%) to \$94.9 million. Employee benefit expenses was the largest increase, up by \$4.4 million as full-time equivalent staff increased by 46 to 422. This reflects additional staff required for the new National Geohazards Monitoring Centre and additional roles created under the new organisation structure which took effect from 1 April 2019.

GNS Science continues to be in a healthy financial position with \$17.6 million of cash reserves at balance date.

We have made clear, strategic choices about the areas of research we will prioritise and invest in over the next five years to progress towards a Cleaner, Safer, More Prosperous New Zealand. This includes investing in Data Science and Social Science to reflect the changing nature of science and enable a greater focus on people-centred research and interdisciplinary research.

WORKING WITH OTHERS

Our work relies heavily on the research partnerships and collaborations we form both in New Zealand and internationally. We also benefit from the input of end-users into our research, to ensure it hits the mark and has the impact intended.

Many of the projects highlighted in this Annual Report refer to the involvement of our partners and end-users who are key to the success of our work. For example, we are seeking to unlock the potential of New Zealand's renewable geothermal energy resources through close collaboration with the research community, energy sector, iwi/Māori and regional development agencies.

We also have an active outreach programme with activities designed to engage with local communities, iwi and children. One of these was our 2019 GeoCamp which gave students and teachers in the Tararua area the opportunity to learn directly from scientists about the geological forces that have shaped New Zealand.

DEVELOPING A MĀORI ENGAGEMENT STRATEGY

At GNS Science we see engaging with iwi/Māori as an integral part of our work. We are working to embed Vision Mātauranga in our work to unlock, in partnership with Māori, the science and innovation potential of Māori knowledge to benefit all New Zealanders.

Building relationships takes time but is worth the effort. Strong relationships will lead to quality outcomes and will place us in the best position to understand the Māori context, obtain quality and robust research, and provide excellent and reputable products. To get there, the engagement approach must be inclusive and consider the perspectives and cultural values of iwi, hapū, whānau and Māori.

This year, as part of this work, we developed an engagement strategy to enhance our relationships with iwi/Māori. The strategy was informed by input gathered from our scientists and external iwi groups by Māori consultancy firm Te Amokura Consultants. This new strategy will be adopted for new projects and used as a guidance tool for current projects.



NEW MĀORI NAME FOR SUBMERGED CONTINENT

The huge and mostly submerged continent upon which New Zealand sits was given a new dual name during the year — Te Riu-a-Māui/Zealandia. GNS Science has played a big role in bringing the existence of the continent to the world's attention. The continent is 4.9 million square kilometres in size and 94% under water.

We asked Associate Professor Mānuka Hēnare of Auckland University to recommend a Māori name that reflected the nature and position of the continent. We were delighted when he agreed and suggested Te Riu-a-Māui, which literally means the hills, valleys and plains of Māui, who was the great ocean explorer. We are working to have the name widely accepted. Its first major use was at Te Papa Tongarewa's new nature zone — Te Taiao Nature — which opened in May 2019.

AROUND-THE-CLOCK "EYES ON" HAZARDS

A key milestone was the opening of our new National Geohazards Monitoring Centre in December 2018. A cornerstone of the Centre is GeoNet and the information it provides.

Rather than being on-call to respond to hazard events, we now have staff working around-the-clock monitoring potential hazards. This has boosted our capacity to monitor New Zealand's main geological threats — earthquakes, volcanoes, tsunamis and landslides. It means robust and reliable information can be delivered quickly to key decision-makers and to the public. Being able to do this in a very timely way will help to enhance the safety of New Zealanders.

The new Centre has been years in the making. It was first envisaged in 2012 in an international strategic review of GeoNet, but the project gained momentum after the 2016 Kaikōura earthquake and tsunami. Its opening was the culmination of input from our partners and end-users, and is an excellent example of what can be achieved when government agencies work together. It is a future-focused initiative that New Zealand can be proud of.

RESILIENCE TO NATURE'S CHALLENGES

GNS Science hosts Resilience to Nature's Challenges, one of 11 National Science Challenges that began in 2014. Its role is to research and apply new scientific solutions to transform our response, recovery and bounce-back from a wide range of natural hazards.

During the past four years, more than 100 researchers from several organisations have worked on 40 projects across multiple disciplines. Following a positive mid-term review, the Challenge was awarded funding of nearly \$40 million from the Ministry of Business, Innovation and Employment for an additional five years from July 2019. The review recognised the Challenge's end-user focus, its high-quality multidisciplinary science outputs, and the value of its science communication.

We would like to thank Ian Fraser, who completed his term as the Chair of the Governance Group this year, for his role in the establishment and success of the Resilience Challenge. We would also like to thank Professor Shane Cronin for his leadership during the first phase of the Resilience Challenge.

Under the Challenge's new five-year strategy, the work of our Natural Hazards Research Platform is being incorporated into the Challenge. Previously, the work of the Platform ran in parallel. The outcomes from the Platform's work will support research planned in the next phase of the Challenge. During the year we welcomed Jenn Bestwick as the new Chair of the Governance Group of the Resilience Challenge, and Richard Smith as Director of the Challenge.



CHANGES TO THE GNS SCIENCE BOARD

Professor Steve Weaver retired from the Board at the end of June 2019. We would like to thank Steve for his dedication and invaluable service to GNS Science over the past nine years.

LOOKING AHEAD

Even though this has been a period of change, our scientists have had another very productive year delivering high-quality science and landmark projects that make a difference for New Zealanders. The significant impact of this work and the value of our many partnerships and collaborations is evident in the projects featured in this Annual Report.

Looking ahead, our strategy is simple — support our people to do their jobs, build on what we do well, and focus our efforts on what matters to New Zealanders. To deliver on this we need to continue to do excellent science and ensure it is relevant and has impact.

Through an increasingly proactive approach and external engagement led by a clear strategy, we are well-placed to navigate the ever-changing nature of science, technology and society.

Dr Nicola Crauford
Chairman
September 2019

Ian Simpson
Chief Executive
September 2019

OUR
442 STAFF
ARE LOCATED IN



83% LOWER HUTT

14% TAUPŌ

2% DUNEDIN

1% AUCKLAND

OUR
\$95.3M
REVENUE during 2018-19
was generated from:

36%

direct government funding for research

15%

contestable public-good research contracts

36%

consultancy services, product development, and analytical services for the private sector, and for central and local government

13%

GeoNet's monitoring of geological hazards for New Zealand

➤ Visit our website: www.gns.cri.nz

HONOURS AND AWARDS

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



2018 SCIENCE NEW ZEALAND NATIONAL AWARDS

These annual awards for the seven Crown Research Institutes recognise outstanding achievements in science that produce benefits for New Zealand.

Principal Scientist and earthquake geologist **Kelvin Berryman** won a Lifetime Achievement Award in the 2018 Science New Zealand National Awards for a distinguished career in advancing the disciplines of active tectonics and earthquake hazard.

The **Tectonics and Structure of Zealandia Programme Team** won a Team Award in the 2018 Science New Zealand National Awards. The team of 36 scientists has achieved major advancements in scientific knowledge and increasing public awareness of living on the plate boundary. They developed the first 3D seismic velocity model of New Zealand's brittle crust and discovered the slow-slip earthquakes on the Hikurangi subduction zone. Their research has been widely cited within the global research community since 1998.

Natural hazards planner and policy researcher **Wendy Saunders** received the Early Career Researcher Award in the 2018 Science New Zealand National Awards. Wendy has developed a practical land-use planning framework for councils to manage their natural hazards. She was appointed to the National Climate Change Risk Assessment panel convened by the Ministry for the Environment, and the Wellington City Council Mayor's Insurance Taskforce.



Climate scientist **Nancy Bertler** was appointed inaugural Director of the newly established Antarctic Science Platform. This appointment recognises her experience and reputation in the national and international science community, and GNS Science and Victoria University as New Zealand's leaders in Antarctic research.

Geochemistry technician **Karen Britten** won the Kingma Award, which is awarded to the most outstanding New Zealand earth science technician of the year, for work on volcano monitoring.

Geothermal specialist **Brian Carey** was awarded honorary life membership of the New Zealand Geothermal Association in recognition of more than 25 years' involvement in geothermal energy development.

Principal Scientist **Cornel de Ronde** received the Excellence Professorship award from the Petersen Foundation in Germany. The award recognises Cornel's outstanding contributions in the fields of marine geology and science communication.

Seismologist **Bill Fry** was named as the Hochstetter Lecturer for 2019. The Hochstetter Lecture is delivered around the country by a New Zealand Earth scientist 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.

Remote-sensing scientist **Ian Hamling** won the New Zealand Geophysics Prize for a paper he led last year on the 2016 Kaikōura earthquake that was published in the journal *Science*.

A collaborative paper led by climate scientist **Elizabeth Keller** featured on the front cover of the international science publication *Nature*. The paper focused on the global environmental consequences of 21st Century ice-sheet melt.

GNS Science was recognised by the international science publication *Nature* as the top-ranked corporate institution in the world for the number and quality of our publications in Earth and environmental science. We were also ranked 14th overall for our publication output across all science disciplines. The annual *Index* tables by *Nature* are a measure of high-quality research output by corporate, government and academic organisations throughout the world.



VOLCANOLOGIST JOINS SCIENCE ADVISORY FORUM

Volcanologist **Gill Jolly** joined the Forum of Chief Science Advisors working with the Prime Minister's Chief Science Advisor, Juliet Gerrard. Gill brings expertise in volcanology and natural hazards, including experience in providing advice to governments on science issues related to risk, disaster preparedness and response.



NEW ROYAL SOCIETY FELLOW

Geophysicist **Laura Wallace** was elected as a Fellow of the Royal Society Te Apārangi, recognising her true international distinction in research, scholarship and the advancement of knowledge. Laura's research and leadership have helped place New Zealand at the forefront worldwide for studies on tectonic plate boundary processes. Laura was also awarded the McKay Hammer, an annual award for "the most meritorious contribution to geology published in the previous three calendar years" for a series of significant papers on understanding slow-slip earthquakes on the Hikurangi Margin.

Hazard and risk management researcher **Sally Potter** received an award for Excellence in Emergency Communication Research at the 2018 Emergency Media and Public Affairs conference in Wellington. Sally's research focused on best practice in writing short warning messages for the public during emergencies. Findings have been used by the Civil Defence and Emergency Management sector for New Zealand's new emergency mobile alerts.

Groundwater scientists **Vanessa Trompetter** and **Rob van der Raaij** won Best Overall Poster Presentation at the 2018 joint NZ Hydrological Society and Meteorological Society of NZ conference for a poster titled 'A Groundwater Isoscape for New Zealand'.

GNS Science's Wairakei geothermal team was part of a team that won the New Zealand-Taiwan Business Excellence Award for their work enabling Taiwan to meet its renewable energy goals.

Groundwater modeller **Paul White** was appointed to the Taupō Nui-a-Tia Management Board by the Minister of Conservation Hon Eugenie Sage. The Board represents iwi and community interests to manage the Taupō Waters as if they were a reserve for recreation purposes.

Three of our 17 contestable research programmes were given a gold rating by the Ministry of Business, Innovation and Employment in 2018. Every year MBIE rates a contract's performance as red, amber, green or gold, with gold signifying performance exceeding expectations. The Natural Hazards Research Platform hosted by GNS Science was rated gold for the fourth year in a row. Gold ratings were also awarded to the Hikurangi Subduction Earthquakes and Slip Behaviour programme, and the Smart Models for Aquifer Management programme (see pages 42 and 26 respectively).

ABOUT GNS SCIENCE

ABOUT US

GNS Science, Te Pū Ao, is a 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 New Zealand by:

- building intergenerational wealth and wellbeing through wise custodianship of 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 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.

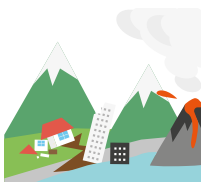
Providing excellent science, where it matters most

*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.

Science theme

NATURAL HAZARDS AND RISKS

How these impact 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

Science theme

ENVIRONMENT AND CLIMATE

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



Science theme

ENERGY FUTURES

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

Science theme

LAND AND MARINE GEOSCIENCE

Underpinning knowledge of 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

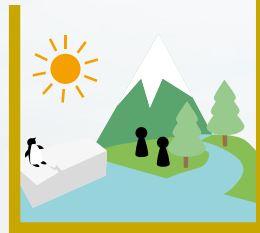
OUR SCIENCE

We deliver world-leading science that has a positive impact on the lives of New Zealanders, providing a Cleaner, Safer, More Prosperous society for everyone.

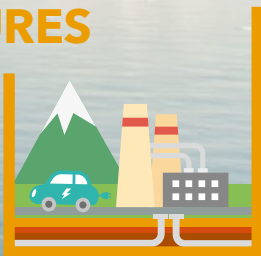
NATURAL HAZARDS AND RISKS



ENVIRONMENT AND CLIMATE



ENERGY FUTURES




LAND AND MARINE GEOSCIENCE



SCIENCE THEME

NATURAL HAZARDS AND RISKS

Natural hazards are part of New Zealand's DNA – and climate change is increasing both the risks and the impacts of hazard events.



Managing our increasing exposure to these natural hazards is critical to our future wellbeing and prosperity. GNS Science ensures that our management of these risks is based on scientific evidence. Our extensive knowledge of Earth sciences, combined with social science research into communication, resilience and preparedness, helps us span the full value chain of information.



Getting better prepared for the threat of tsunamis

Our tsunami scientists have developed a database of more than 700 tsunami scenarios and maps that can be used for tsunami warning purposes for New Zealand. The database consists of modelled seafloor earthquakes in subduction zones right around the Pacific Rim capable of producing a tsunami of one metre or greater at the New Zealand coast.

Pre-calculated scenarios are not new, but in the past year we have more than doubled their number and added more detail, so they are more useful to responding agencies.

When an earthquake occurs in a subduction zone around the Pacific, the nearest scenario in the database can be called up to provide an early estimate of the height of a tsunami and arrival time at the New Zealand coast. As more detail on the size, depth, location and mechanism of an earthquake becomes available, the initial estimate can be refined to provide a more accurate threat assessment of an incoming tsunami.

There are 43 zones for each scenario around the entire New Zealand coast, with each zone potentially having a distinct threat level for a particular tsunami. We will continue expanding the number of modelled scenarios in the database, so it covers a greater range of earthquake possibilities and tsunami sizes.

PUBLIC WORKSHOPS ON TSUNAMI EVACUATION

Aligned with this work, the 'Quicker and safer tsunami evacuations through agent-based modelling' project has been involved in public workshops in Napier, Petone, and Sumner to help improve tsunami evacuation planning for communities. The workshops show computer simulations of the movement of people during evacuations and encourage feedback from the public.

The project encourages people to familiarise themselves with evacuation routes they would use in the event of a tsunami. Walking or cycling their preferred route will help to identify any potential obstacles along the way.

A core message in these workshops is 'Long or strong — get gone'. If people feel a strong quake that makes it hard to stand up, or a weak rolling earthquake that lasts a minute or more, they should move immediately to the nearest high ground, or as far inland as they can. They should walk or bike if possible. Don't wait for official warnings.

"The tsunami scenarios and maps GNS Science has developed will help us to provide timely information when large earthquakes occur to those who live, work in or visit New Zealand to help them keep themselves and their families safe."

**Sarah Stuart-Black,
Executive Director, Ministry of Civil Defence
and Emergency Management**

**700+
TSUNAMI
SCENARIOS
& MAPS**





NATIONAL GEOHAZARDS MONITORING CENTRE GOES LIVE

A new purpose-built facility hosted by GNS Science is providing enhanced around-the-clock monitoring of major geological hazards to help keep New Zealanders safe.



'EYES ON' AROUND-THE-CLOCK

The National Geohazards Monitoring Centre Te Puna Mōrearea i te Rū was blessed in a dawn ceremony by Te Atiawa and opened by Research, Science and Innovation Minister Hon Dr Megan Woods and Civil Defence Minister Hon Kris Faafoi in December 2018.

The Centre is staffed 24/7 to provide timely advice and intelligence about hazard events to decision-makers in natural hazard management response agencies. It covers four types of hazards — tsunami, earthquake, volcano and landslide — and is, we believe, the first centre in the world to monitor all these geological hazards together.

“Kiwis can now feel reassured that there will be experts keeping an eye on our geological hazards every minute of every day.”

**Hon Kris Faafoi,
former Minister of Civil Defence**

When a serious event happens, every second counts, meaning the work of the Centre could potentially save lives. Previously we relied on automated messages to on-call staff. Being on-site all the time allows our staff to immediately assess events as soon as they begin, improving awareness of what is happening and response times.

The service builds on decades of work we have done with the Earthquake Commission and Land Information New Zealand.

The Centre is funded through the Ministry of Business, Innovation and Employment’s Strategic Science Investment Fund and was built with support from the Ministry of Civil Defence and Emergency Management, the Earthquake Commission and Land Information New Zealand. It is located on our campus in Lower Hutt but designed to be resilient, with a back-up facility at our Wairakei site and at GeoScience Australia.

Improving geohazards monitoring and resilience in the Pacific

GNS Science is the go-to specialist in geohazards monitoring in the Southwest Pacific. We take pride in our role of helping New Zealand be a good neighbour in the Pacific.

In **Vanuatu** we completed a long-term project to build a volcano monitoring network and improve geohazards monitoring capabilities. When the project started in 2011, the islands had only limited resources for volcano monitoring. Building a long-term sustainable solution was a priority of the Ministry of Foreign Affairs and Trade-funded project. As well as a telemetered national seismic network with near real-time earthquake location capabilities, Vanuatu now has webcams and gas monitoring at key active volcanoes. It is widely regarded as a regional leader in hazards monitoring and provides assistance to other island nations.

In the **Solomon Islands** we helped set up the country's first geohazards monitoring network to provide real-time information on earthquakes, volcanoes and tsunamis.

Funded by the Solomon Islands Government with a World Bank grant, we installed new permanent seismic



monitoring equipment in six of the nine provinces, and helped to set up a monitoring centre in the capital Honiara. The new network has enabled the Solomon Islands to both contribute to and receive seismic data from other countries in the Southwest Pacific, improving the vigilance of the region.

As well as Vanuatu and the Solomon Islands, we have also assisted Samoa, Tonga, Vietnam and Indonesia in building their capacity to monitor and mitigate geological hazards.

Science brought to life in cutting-edge exhibition



As a founding partner of New Zealand's national museum Te Papa Tongarewa, we were excited to contribute our world-leading expertise to the museum's new \$11 million nature exhibition.

Te Taiao Nature opened in May 2019 and weaves Māori knowledge with the latest scientific understanding to bring to life New Zealand's natural history.

More than 20 of our scientists contributed to the design and creation of the geology, geohazard and climate change displays.

The exhibition is the first time Te Riu-a-Māui/Zealandia, the vast undersea continent upon which New Zealand sits, has featured prominently in a museum.

Other highlights include a sloshing two-metre long tsunami tank and a cinematic visualisation of the violent eruption that created Lake Taupō.

Working with the museum's curators, our science was brought to life through vivid storytelling, artwork and interactive displays. This reflects not only our strong partnership with Te Papa, but also with others including the Earthquake Commission and the Ministry of Civil Defence and Emergency Management. And, because millions of visitors pass through Te Papa's doors each year, the exhibition is a great example of connecting our science with the public — for many years to come.

RiskScape — a world-leading risk modelling tool for New Zealand



With our project partners NIWA and the Earthquake Commission (EQC), we are further developing a world-leading software tool for modelling natural hazard risks. Known as RiskScape, the open access software enables users to assess risk to buildings, infrastructure and people from natural hazards such as earthquakes, tsunamis, and floods.

RiskScape draws on decades of accumulated hazards knowledge to help users with decisions about planning and mitigation. It is designed to perform complex calculations simply and quickly without needing specialist modelling knowledge. GNS Science and NIWA jointly developed RiskScape and EQC recently joined the partnership. The next update of the tool is due for release in mid-2020.

The software enables users to create a natural hazard scenario through simple steps. Results can include the number

of exposed buildings, the degree of damage and economic loss, as well an estimate of human casualties. It can also estimate the disruption to lifelines, such as electricity, road, and water networks.

As well as being used in New Zealand cities, RiskScape has been used in Samoa to quantify flooding risk in the catchment of the Viasigano River — the main waterway through the capital Apia. The information is informing emergency evacuation planning and flood response procedures. It has also been used in Indonesia to assess building impacts from a tsunami affecting coastal areas of Palu on the island of Sulawesi.

For more information on RiskScape software, see: riskscape.org.nz

Earthquake ground shaking in Wellington

Some mid-rise buildings in central Wellington experienced significant damage because of the magnitude 7.8 Kaikōura earthquake in 2016.

The city's sedimentary basin, as well as the source of this particular earthquake, had a critical influence on ground motions and damage patterns during the earthquake.

Using a wealth of new geological and geophysical data, our scientists developed a new 3D geological model of Wellington's subsurface and updated the city's geotechnical maps. They discussed the results with interested parties including Wellington City Council, the Earthquake Commission, the Ministry of Business, Innovation and Employment, and engineering consultancies.

The model and maps are now being used to guide engineering solutions that accommodate the effect of different soil types on earthquake ground-shaking in Wellington.



Not only will they help us better understand and predict patterns of earthquake ground-shaking, but they will also enable the city to be better prepared to mitigate future damage.

This project was funded by the Natural Hazards Research Platform and conducted in collaboration with The University of Auckland.



High-profile landslides, high-tech expertise

GNS Science's landslide expertise was called on in two high-profile events this year: the Cape Kidnappers cliff collapse in Hawke's Bay and the Kaiwhata landslide dam in Wairarapa.

In January 2019 our landslide team collected data about the collapse of cliffs along a beach track to the Cape Kidnappers gannet colony. The team put together a 'change model' using LiDAR (light detection and ranging) data to show the impact and volume of previous

collapses. Our work enabled Hastings District Council and the Department of Conservation to maintain public safety, and prepare a long-term risk management plan.

In June 2019 a large landslide blocked the Kaiwhata River close to Wairarapa's east coast. A lake with more than 500,000m³ of water formed behind the landslide dam, posing a significant hazard to residents and landowners down-river.

GNS Science worked with Greater Wellington and the Masterton and Carterton District Councils to monitor the landslide dam and model what would happen if it failed rapidly. This advice helped the community develop a risk management plan.

Two weeks later, the landslide dam did fail suddenly — behaving exactly as we had forecast. Data gathered from this event will help prepare for future events.



10 Years – Natural Hazards Research Platform

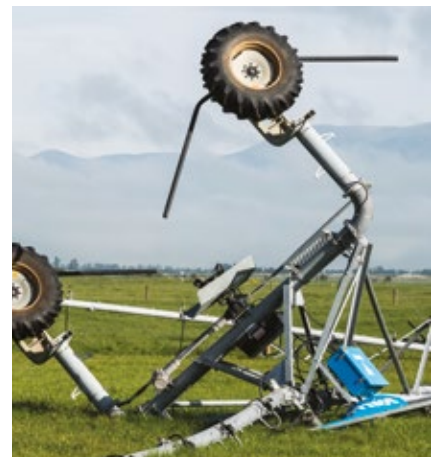
This year was the final year of the Natural Hazards Research Platform – a programme of work established in 2009 by the New Zealand Government to provide long-term funding for natural hazard research, and to help researchers and end-users work more closely together.

Over its 10-year life, the Platform worked to increase New Zealand's resilience to natural hazards. The team combined the efforts of the geophysical, engineering and social sciences to address risks from natural hazards, while working more closely with end-users for delivery of the research outputs.

Over that time, we saw an increased number of natural hazard events. A number of notable earthquakes, volcanic eruptions, extreme weather causing wind, flood, and storm damage – all of these impacted on people and infrastructure. The Platform was the first programme of its kind in New Zealand and could be considered the 'pilot' for the National Science Challenges, including Resilience to Nature's Challenges, which will continue the good work done under the Platform to enhance New Zealand's ability to anticipate, adapt and thrive in the face of ever-changing natural hazards.

The research has also been influential overseas. Tsunami blue lines now exist in the west coast of the USA and parts of Indonesia. And how we communicate earthquake aftershock forecasts has been received with great interest by colleagues in Japan and the USA.

The Platform has been led by GNS Science, with NIWA as a co-anchor organisation, and Opus Research, and the Universities of Canterbury, Massey and Auckland as partners. Collaboration extends more widely with subcontracts to other parties.





Resilience to Nature's Challenges

GNS Science hosts Resilience to Nature's Challenges, one of 11 National Science Challenges established to tackle big issues that affect all New Zealanders.

The Challenge aims to enhance our ability to anticipate, adapt and thrive in the face of ever-changing natural hazards.

The Challenge entered a second phase from July 2019 with \$39.8 million funding from the Ministry of Business, Innovation and Employment for an additional five years. Phase 1 of the Challenge (2015-19) drove research across 10 interdisciplinary areas. 'Co-creation Laboratories' saw researchers, users and stakeholders develop resilience solutions in the Rural, Urban, Māori and Edge (coastal) environments. These Laboratories were supported by technical solutions which were developed and applied across the greatest priority areas.

HIGHLIGHTS FROM PHASE ONE

- working with livestock farmers and winegrowers in North Canterbury and Marlborough to build resilience following the 2016 Kaikōura earthquake
- developing a New Zealand Resilience Index which assesses the resilience of communities over time
- piloting Transport Corridor Forums to increase the resilience of our transport infrastructure
- creating a Wildfire Hazard Index allowing wildfire hazards to be compared with other perils
- developing a national electricity distribution network resilience guide
- working with hapū and iwi to develop new resilience indicators for Māori assets.

A major forum held at Te Papa in May 2019 showcased the collaborative research into hazards and resilience over the past 10 years and outlined future research.

Phase 2 of the Resilience Challenge will focus on two major themes that align with the Government's new National Disaster Resilience Strategy. Exciting new research to advance our understanding of natural hazards will comprise the Multi-hazard Risk Model. Improved knowledge of our disaster risks will be paired with social, economic and cultural research to develop tools and methods designed to build Resilience in Practice.

The Resilience Challenge is well-placed to continue producing high-quality research that can be widely used to improve New Zealand's natural hazard resilience.

RESILIENCE
TO NATURE'S
CHALLENGES

Kia manawaroa
– Ngā Ākina o
Te Ao Tūroa

National
SCIENCE
Challenges

SCIENCE THEME

ENVIRONMENT AND CLIMATE

We take an integrated approach on the environment, combining environmental change, climate change, and groundwater.



The quality and availability of groundwater is fundamental to the quality of life in New Zealand. Forty percent of New Zealanders depend on groundwater for drinking water. In climate research, we take a global leadership role in collecting and analysing data that exists naturally in our geology. This work plays a vital role in informing management and adaptation strategies for the future.





A full carbon budget for New Zealand

“What makes CarbonWatchNZ so vital is that doing this work is not just about scientific discovery, it is work that will make a real difference in people’s lives.”

**Dr Sara Mikaloff-Fletcher,
Atmosphere-Ocean Scientist, NIWA**

NEW ZEALAND IS THE FIRST COUNTRY IN THE WORLD TO DEVELOP A NATIONAL-SCALE PICTURE OF A COUNTRY’S CARBON BALANCE.

To combat climate change and assess the impact of government policies, we need to be able to measure greenhouse gas emissions.

Specialists at GNS Science are collaborating on a world-first project: the development of a complete top-down picture of New Zealand’s carbon balance.

CarbonWatchNZ is a five-year project that will combine measurements of greenhouse gases in the air above New Zealand with high resolution atmospheric models that show where the gases have come from. New Zealand is the first country in the world to develop a national-scale picture of a country’s carbon balance.

GNS Science has already done some pilot work in Auckland using radiocarbon measurements to develop a full carbon budget for the city and prove the methodology. The good news from this work is that Auckland’s carbon sink (trees and other vegetation) may be offsetting more carbon than was first anticipated. The study is being expanded as part of the wider CarbonWatchNZ project.

This new nationwide project will measure our two main greenhouse gases — carbon dioxide and methane — in the three landscapes that are most important to New Zealand’s carbon balance — forests, farmland and urban environments. There will be 17 continuous measurement sites around the country.

Our involvement is providing land carbon modelling to estimate the carbon exchange between the land and forests, and measuring greenhouse gas emissions on the urban scale. GNS Science has particular expertise in radiocarbon measurements. These allow us to separate the carbon dioxide from fossil fuel burning versus carbon dioxide from biogenic exchange (through photosynthesis and respiration).

The information from these measurements will be crucial in making good decisions about carbon mitigation strategies both nationally and regionally. In Auckland, Ngāti Whātua Ōrākei have engaged with the project to help understand the benefits of their ongoing native tree planting work on their land.

CarbonWatchNZ is a globally recognised project funded by MBIE’s Endeavour Fund and involving our partners NIWA, Manaaki Whenua-Landcare Research, Auckland Council, and the University of Waikato. Information from the project is used in Ministry for the Environment reporting to the United Nations about New Zealand’s work to meet its obligations as a signatory to the Paris climate change agreement.



Keeping a watch on freshwater contaminants

Emerging Organic Contaminants are a recently-recognised class of chemicals that can affect freshwater quality, and human and aquatic health.

Our groundwater team partnered with the Waikato Regional Council and the British Geological Survey to examine aquifers in the Waikato. The pilot project sampled more than 50 bores throughout Waikato, testing for the presence of these contaminants.

The contaminants are natural or manufactured chemicals that are commonly found in household and personal care products, pharmaceuticals and agrichemicals. They are classed as 'emerging' as a result of improved analytical techniques and better monitoring. Our survey provides the first region-wide measurement of these contaminants in New Zealand groundwater to inform future monitoring beyond standard tests for pesticide presence.

The Waikato pilot survey screened groundwater samples for the presence of 723 compounds to establish a baseline and to inform future monitoring regimes. Seventy-three compounds were detected at 91% of sites, with rates ranging between one and 31 compounds per site. Twenty-eight compounds were measured at concentrations above the EU maximum admissible levels for total pesticides for drinking water.

Dominant contaminant types identified include pesticides, pharmaceuticals, industrial compounds, preservatives/food additives, and personal care products. Concentrations were similar to those found in groundwaters overseas, where regulatory organisations are placing restrictions and bans on the use of selected contaminants.

GNS Science now wants to extend the survey to other regions in New Zealand. Our groundwater scientists anticipate there will be regional differences in contaminant makeup and concentrations based on land use and the mix of industries in particular areas.

"This is definitely a great piece of work that is going to be very useful for informing further work in this area."

John Caldwell, Senior Scientist for Science and Strategy, Waikato Regional Council



EXPLORING THE PAST AND PRESENT HEALTH OF NEW ZEALAND'S LAKES

Many of New Zealand's lakes are deteriorating in health, yet our ability to make informed assessments at a national level is constrained by a lack of critical knowledge about our lakes' current and historic health. Of the country's 3800 lakes, we currently have scientific knowledge for fewer than five percent.

To help address this knowledge gap, researchers from GNS Science and the Cawthron Institute are leading a five-year collaborative project to scientifically characterise the health of 10% of New Zealand's lakes.

Called 'Lakes380: Our lakes' health — past, present, future', the project is the biggest scientific study of New Zealand's lakes ever undertaken. It relies on strong research partnerships with Victoria University, University of Otago, Waka Taurua Ltd, Matana Consulting, Ngāti Kahungunu ki Wairarapa, The University of Auckland, more than 10 international organisations, and iwi around the country. The project combines biophysical and social sciences expertise with mātauranga Māori knowledge.

In addition to characterising present biodiversity and water quality, the team is exploring how and why the lakes have changed over the past 1000 years by collecting and analysing sediment cores. Sediment in a lake is laid down year-by-year. Layers preserved in the cores are like pages of a history book that record environmental change, weather events, vegetation changes and human impacts. They extend our knowledge over centuries, well beyond the instrumental era.

DATA COMBINED WITH MĀTAURANGA MĀORI

Data from the sediment cores and other samples collected will be interwoven with mātauranga Māori to provide a richer understanding about the value and health of New Zealand's lakes, as well as the impact of natural and human activity. In each study region, the project team is working with iwi and hapū to learn from their mātauranga and oral histories that draw upon long associations with the lakes. This sharing of mātauranga will help enrich and inform joint aspirations for protection and restoration.

The team has so far sampled more than 100 lakes including those at the northernmost tip of New Zealand. In June 2019 the Lakes380 team partnered with Ngāti Kuri to sample five lakes in Northland which have high cultural significance and were important sites for mahinga kai (traditional food gathering).

The knowledge gathered will be used to help predict future changes and ensure protection and restoration efforts nationally are culturally and ecologically appropriate. The project is a great example of how we work with local communities and how our science can make a real difference.



"The knowledge gained will help us implement the best systems we can to protect our unique biodiversity, manage our biosecurity and enhance our relationship with these precious taonga."

**Harry Burkhardt,
Ngāti Kuri Trust Chairman**

Lakes380 is funded through the Ministry of Business, Innovation and Employment's Endeavour Fund. For more information: [Lakes380.com](https://www.lakes380.com)

Better modelling to support decision-making for groundwater management

Groundwater models provide essential information for the management of New Zealand's freshwater resources. However, existing models too often suffer from being too data hungry, too slow, and too costly. When designed inappropriately models can provide inaccurate information, undermining any management decisions relying on their output.

The GNS Science-led Smart Aquifer Management programme is a collaboration with many other organisations. It has led to the development of a world-leading framework, strategies and tools to improve the cost-effectiveness and reliability of the management of New Zealand's aquifers via groundwater models.

There are about 200 known aquifers in New Zealand and groundwater currently accounts for about one-third of all freshwater usage. Councils are increasingly relying on models for decision-making, so our new outputs from this programme are timely.

These outputs provide new guidance on modelling design and uncertainty quantification for decision support applications. Applications include the management of land and water use to minimise the impact of human activity on systems of ecological, environmental, cultural and economic importance.

During this three-year Ministry of Business, Innovation and Employment-funded project, we designed, developed and tested the performance of a range of case-study numerical models for Wellington, Southland and Waikato regional councils. These models aim to help councils address real management

challenges when setting allocation limits for land and water use. The results from these studies provide insights into the source of uncertainty in numerical groundwater models. They clarify how to design models that retain salient components and remove superfluous components, to allow quicker and cheaper decision-making support.

“The whole process has been invaluable for many reasons. I'm looking forward to the results further unfolding.”

Dr Tim Ellis, Senior Science Co-ordinator, Environment Southland

The programme provided guidance for selecting the most appropriate modelling approach for addressing management problems, with an aim to reduce the duration and cost of modelling studies. Importantly, it reduces the number of erroneous modelling predictions. Central government and iwi also provided input.

Our groundwater scientists estimate the new developments will deliver annual improvements valued at about \$350 million to New Zealand. Partner organisations throughout the project included NIWA, ESR, Victoria University of Wellington, Market Economics Ltd, the US Geological Survey, and Watermark Numerical Computing in Australia. This project is a good example of GNS Science's leadership in groundwater modelling and science.



Predicting the impacts of sea level rise

New Zealand's ability to adapt to climate change depends on accurate predictions about what will happen — and what we can do to manage the impacts. A five-year programme jointly led by Victoria University of Wellington, GNS Science, and NIWA aims to improve predictions about how sea level rise will affect our coasts over the next several hundred years.

The New Zealand SeaRise project will fill knowledge gaps that currently stop us from anticipating and managing the impacts and risks of future sea level rise.

Predicting sea level change is complex. There is broad agreement that global warming is causing ice sheets and glaciers to melt and ocean waters to expand — and as a result, sea levels are rising and will continue to do so. But there are many uncertainties.

It is not yet clear how rapidly Antarctica's sea ice will melt, and changes to sea level will not be uniform across the planet. Our preliminary work suggests that sea level close to Antarctica's coast will initially rise faster than the global mean. This local variability is partly due to the gravitational attraction between the ice sheets and the ocean, but also reflects the impact that changes in surface mass have on the shape of Earth's crust.

Tectonics also play an important part in forecasting local sea level change. Aotearoa's coastline is constantly changing, with some areas rising or falling as much as 3-4 millimetres per year. SeaRise will use data from our national network of GPS receivers and information from radar systems to determine how much the land moves. These location-specific forecasts will help assess the impact on New Zealand's coastal areas.

We are currently investigating how rising seas will affect groundwater levels in south Dunedin. We are also working with iwi in Hawke's Bay to examine how sea level rise might alter the distance that salty water can flow up coastal river systems and potentially affect important ecosystems.

Change is inevitable, but excellent science can help us adapt. The projections generated through the SeaRise project will help assess the full range of impacts and solutions we need to deal with inevitable change around New Zealand's vast coastline.

➤ To find more information on the NZ SeaRise project, see: searise.nz





Understanding Antarctica's role in a wilder and warmer world



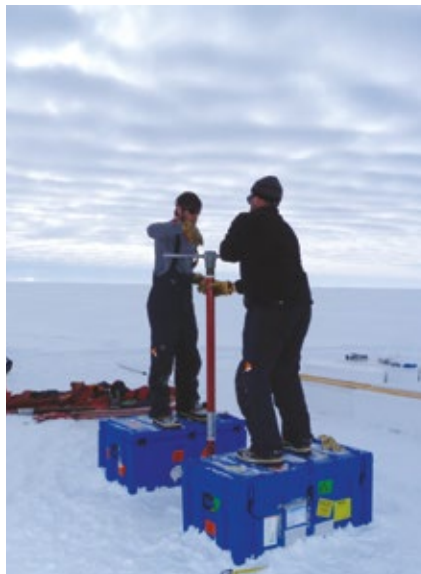
GNS Science is working with researchers in New Zealand and overseas to tackle pressing environmental questions about ice sheet melt and the impact of climate change on the Antarctic and Greenland.

Extreme and unpredictable weather globally will get worse as ice sheets in the Antarctic and Greenland continue to melt. This was the key finding of an international research collaboration published in *Nature* in February 2019. The collaboration involved scientists from GNS Science, Victoria University of Wellington's Antarctic Research Centre, Canada, UK, Germany and USA.

Using climate models, the researchers simulated what might happen when melt water enters Earth's oceans. Under current policy settings, the Earth's temperature will increase by

3 to 4 degrees by 2100 meaning a large amount of water from the Antarctic and Greenland ice sheets will enter our oceans. This will have very disruptive effects for agriculture, infrastructure and human life which are not currently accounted for in global climate policies.

The effect of ice sheet melt on rising sea level was also calculated in the study, with sea level rise from ice sheet melt accelerating in recent years. Experiments showed that if we drastically reduce carbon emissions, we can limit future impacts.



NEW SCIENCE TO UNDERSTAND ANTARCTIC CHANGE IN A 2°C WARMER WORLD

GNS Science is co-leading two new projects as part of the Antarctic Science Platform. We will collaborate with Victoria University of Wellington, Otago University and NIWA to improve our understanding of change in Antarctica if we manage to meet emissions targets set at the Paris climate change summit and keep warming to no more than 2°C above pre-industrial levels.

The Antarctic Ice Dynamics project aims to improve our knowledge of ice sheet response to a warming climate. The project team is developing a new drilling system to enable scientists to

take samples from remote locations not fully explored before. It will be deployed in the centre of the West Antarctic ice sheet where the ice sheet goes afloat. Drilling here will provide evidence about the history of the ice sheet and help forecast future sea level rise with greater accuracy. This work will contribute to other key studies that aim to help New Zealand manage and adapt to change along our coastline.

The Sea Ice and Carbon Cycle Feedbacks project is investigating the impact of climate change on sea ice, biological productivity and carbon dioxide uptake in the Southern Ocean. The ocean currently acts as a 'carbon sink', taking up a large

portion of the carbon dioxide emitted into the air from human activity. We need to know if the carbon sink is changing size and whether it will continue to be a sink. This requires more year-round observations to build a fuller picture. The work will produce science that will underpin decisions about our changing climate system.

SCIENCE THEME

ENERGY FUTURES

Developing innovative approaches to energy to secure a clean and sustainable future.

As 'the Energy Crown Research Institute', GNS Science is a key player in enabling New Zealand's transition to a low-carbon future. Our expertise in Earth science allows us to develop new and innovative uses for geothermal energy, and we also focus on new technologies for energy generation and storage. This work is aimed at enhancing energy security, increasing economic competitiveness and lowering our carbon footprint.





Improving energy efficiencies for industry

GNS Science believes New Zealand's energy future needs innovative thinking — not just in alternative clean-tech generation, but in reducing overall demand for energy. Our materials science work is providing solutions for industry, finding efficiencies for a variety of sectors.

“This advanced materials processing technology has global applications in dairy and other primary industries as it potentially solves a significant pain point for many primary processing companies resulting in enhanced environmental outcomes.”

Brian McMath, Business Development Manager, NZ Product Accelerator

The dairy industry is a cornerstone of New Zealand's economy and our expertise in modifying surfaces at the atomic level is helping to streamline processes — and reduce operating costs.

Interrupting production for regular cleaning of equipment in the dairy processing industry is costly. It requires down-time, leading to lost production, and the cleaning itself takes a significant amount of energy. Our mission is to modify the surface of stainless steel so dairy products don't stick to it.

The process involves bonding atoms to the substrate to change the properties of the substrate surface. A key component in the project is our ion implanter. It can implant a wide range of elements into metal surfaces, and we believe ours is the only facility in the world that can implant metal sheets 14cm wide and two metres long in one movement.

We are taking a phased approach, starting with a pilot project to test adhesion of dairy products at different temperatures. The bonding process produces a surface with minimal risk of gradual wear, and it will have immediate practical benefit for a number of industries.

This work provides an ideal testing ground to scale up our advanced surface modification technology and open up more materials development for other industrial applications.



Tapping in directly to geothermal heat

GNS Science is a key player in a sector-wide initiative to increase the use of geothermal direct heat in New Zealand.

“GNS Science has played an integral role in growing the momentum around direct geothermal use activity in New Zealand. Their support for the work the Bay of Connections has undertaken in this area is leading to significant economic development outcomes for the region.”

Andrea Blair, Geothermal Business Development Lead, Bay of Connections

One of the aims of this initiative is to reduce the reliance on fossil fuels, particularly in industrial settings, and make the country’s energy use greener and more sustainable.

At present, New Zealand uses about 9 Peta Joules (PJ) of energy a year from direct heat from geothermal resources. Our aim is to increase this by more than 30% by 2030.

Direct geothermal heat is used very successfully in timber drying, commercial-scale glasshouses, milk processing, tissue and paper manufacturing, aquaculture, honey processing and bathing. There is considerable scope for further uptake.

In partnership with the New Zealand Geothermal Association, we developed a Geoheat Strategy that sets out steps to build steadily towards an additional 7.5 PJ in primary geothermal energy use. As well as increasing the amount of geothermal used by industry, the initiative is seeking to create about 500 new jobs in regional New Zealand.

We are working closely with the Bay of Plenty Regional Council’s economic development agency, Bay of Connections, and their geothermal business development lead to encourage uptake of direct geothermal use. The focus is on the higher temperature central North Island geothermal resources. While the emphasis is currently on promoting commercial and industrial use, there is also potential for growth in domestic use.

Our involvement has helped to socialise the initiative and we provide leadership, organisational and technical assistance where needed.

NEW BUSINESSES USING GEOTHERMAL DIRECTLY

Two new enterprises have recently joined the list of those benefitting from direct geothermal use. The first is craft brewing operation Rogue Bore Brewery, which is scheduled to start production in early 2020. Based in the heart of the Wairakei geothermal steamfield just north of Taupō, it will produce beer that is brewed and carbonated using 100% geothermal energy.

The second is Geo40, the first company in New Zealand to successfully extract silica from geothermal fluids in a commercial demonstration plant. Silica produced from Geo40’s plant at Contact Energy’s Ohaaki facility is being sold for use in consumer goods such as tyres, paint, and building materials. This provides an environmentally sound source of silica that would otherwise need carbon-intensive energy to produce. Geo40 recently received a Provincial Growth Fund loan of \$15 million to assist in enlarging production seven-fold.

SUPPORT FOR FAR NORTH GEOTHERMAL ENERGY EXPANSION

Geothermal energy will soon provide more than two thirds of the Far North's peak winter power consumption thanks to GNS Science's specialist expertise in planning geothermal energy developments.

The Ngāwhā Geothermal Power Station near Kaikohe, owned and operated by Top Energy, is in the midst of a \$180 million expansion that will see 31.5MW of power being added to the 25MW it already produces. The new facility is expected to be operating by late 2020.

Our role has spanned the life of the project from feasibility studies to well testing. This started with production of a numerical reservoir model that was used to assess the feasibility and impact of the proposed expansion. Then a detailed 3-dimensional model of the geothermal

reservoir was used to help in the siting of the new wells, all of which were used in the new development. Our geologists were present on the rig during the drilling programme. After the wells were drilled, we developed a test programme and analysed the results to provide estimates of their capacity.

Electricity generated from geothermal energy will play an increasingly important role in New Zealand's energy mix. It offers a renewable energy source that is not susceptible to climatic conditions. Consumption is expected to rise sharply in coming decades as New Zealand electrifies various sectors in moving to a low-carbon future. As the energy Crown Research Institute, we are a vital player in helping to unlock geothermal resources for New Zealand.

"The team from GNS Science was instrumental in the development and delivery of the well drilling programme at Ngāwhā. Their support and responsiveness helped ensure the programme was delivered in a timely manner and our knowledge of the geothermal resource has increased significantly."

Thomas Zink, Project Director, Ngāwhā Expansion Project, Top Energy Ltd





Exploring geothermal as an energy option for the West Coast

A West Coast consortium has tapped into our expertise in geothermal energy to see if geothermal can be part of a wider energy strategy for the region.

Our work consisted of a 10-month preliminary study to assess the size and extent of potential geothermal resources in the region. Lead funder for the study was Development West Coast. Consortium members include local councils, commercial interests, community groups, and iwi groups Te Rūnanga o Ngāti Waewae and Te Rūnanga o Makaawhio.

The peer-reviewed study considered geothermal heat sources that could potentially be used for direct applications such as horticulture, hot pools, accommodation facilities and industrial uses. It also looked at the possibility of small-scale electricity generation.

Our mix of expertise in geothermal geology, modelling, and geochemistry, plus a long association with West Coast geology, enabled us to provide unique insights into the geothermal potential of the region.

SITES FOUND FOR FURTHER INVESTIGATION

This study identified four sites considered worthy of more detailed investigation. They are Franz Josef, Brunner/Moana, Styx River/Kokatahi and Haupiri/Kopara. Locations on the Westland Plains have geothermal fluid temperatures between 60°C and 90°C. Those closer to the 'Alpine Fault Domain' were hotter at the same depth below the surface — 100°C to 130°C — or higher if drilled deeper.

This suggests the Plains sites are best suited for horticulture and tourism activities rather than electricity generation or industrial use, both of which need higher temperatures. Other factors considered were the available workforce, transport networks, land access, and the depth to useable heat at each of the sites. This study has given a solid foundation to the Consortium as it considers future directions for the initiative.

“This is a renewable resource that has almost zero carbon emissions, and currently it’s totally untapped. Looking at the recommendations in the GNS Science study and working with Development West Coast, we estimate that developing these prospects would result in up to 160 new direct jobs on the West Coast, plus other downstream jobs.”

Francois Tumahai, Chairman Ngāti Waewae

Building a better picture of underground heat



GNS Science has perfected a geophysical technique that helps scientists and others gain a better understanding of deep geothermal resources and volcanic hazards in the Taupō Volcanic Zone.

Called magnetotellurics, it maps electrical conductivity of rocks to a depth of 10km or more below the ground. This enables scientists to build a picture of geothermal fluids and magma bodies deep below the surface, and to see the connections between the shallow parts of geothermal fields and the underlying magmatic systems that provide the heat.

Our team has developed an international reputation in the use of this technique. Since 2009 they have collected this electromagnetic data at more than 1000 locations in the central North Island.

“As managers of the geothermal resource, it is important that this type of work was undertaken. For the Regional Council, these data will contribute to our understanding of the wider geothermal resource and volcanic hazard in the region surrounding Rotorua.”

Penny Doorman, Bay of Plenty Regional Council, Geothermal Programme Leader

This year they partnered with Bay of Plenty Regional Council, Te Arawa Lakes Trust and Scripps Institute of Oceanography to collect this geophysical data from four lakes in the Rotorua region – Tarawera, Okataina, Rotoiti and Rotorua. This represents the first ever MT data measured in lakes in New Zealand.

Results will be useful to Māori landowners, regional councils, geothermal companies and scientists studying volcanic hazards.



Transparent window coatings to generate electricity

GNS Science is exploring cutting-edge technology to generate electricity from windows, which will significantly reduce carbon emissions and household energy bills.

This three-year collaboration aims to create an efficient and novel transparent thermoelectric material that can be coated on to windows to harvest electricity. The coatings would exploit temperature differences between the indoor and outdoor environment to produce the electricity used for indoor heating and cooling.

New Zealand homes have approximately 4.5 million square metres of glass panels and windows, meaning the coatings could have wide-reaching benefits locally, as well as internationally.

A key challenge in year one of the project is to develop a coating material that has thermoelectric properties, and is also transparent enough to be used on windows. We will then build

a proof-of-concept window-type device for energy harvesting and test it under simulated conditions. We will measure key parameters such as output power density, optical transparency and efficiency.

Our researchers are working in collaboration with local and international partners including Victoria University of Wellington, Rensselaer Polytechnic Institute (USA), Hong Kong University of Science and Technology, and New Zealand glass manufacturers.

We intend to work with Māori businesses and others who may have the potential to take up the new technology.

Funding for this project was awarded by the Government’s Endeavour Fund in 2018.

NZ HOMES HAVE APPROXIMATELY 4.5 MILLION SQUARE METRES OF GLASS PANELS AND WINDOWS

SCIENCE THEME

LAND & MARINE GEOSCIENCE

The mostly submerged continent of Te-Riu-a-Maui / Zealandia is globally important. Not only for its rich scientific opportunities in tectonics and natural hazards, but also in understanding how our climate has changed and how and where resources are located. Our research has a holistic focus and encompasses environmental, cultural, health, and economic outcomes. The heritage and history of Te-Riu-a-Maui / Zealandia is underpinned by the precious taonga in our Nationally Significant Collections and Databases.





GeoCamp inspires the next generation

Inspiring children to develop a passion for science and encouraging students to consider a career path in science are all part of our community engagement activities.

This year we ran our eighth GeoCamp, a science learning experience for intermediate school children and their teachers. Taking place over two weeks in Tararua District, the camp gave students and teachers from six rural schools the opportunity to learn alongside our scientists as they dug for fossils, inspected fault-lines and measured the impacts of likely sea level rise.

The local community attended a public science expo at the end of the camp, allowing the children to communicate their discoveries and share knowledge with others. By including teachers in the camp, it allowed them to observe how GNS Science staff undertake their science, with the aim of encouraging teachers to use the locations and learnings in their own future teaching.

GNS Science staff developed the GeoCamp programme and led the fieldtrips, supported by funding from commercial partners.

Connecting with the next generation and giving children in rural areas the opportunity to learn with our staff is an important part of growing an awareness of what we do. And it is helping grow future scientists.



Unravelling the mystery of the Pink and White Terraces

The mystery of whether New Zealand's famous Pink and White Terraces — Te Otukapuarangi and Te Tarata — still exist and their exact whereabouts is one step closer to being solved. A first glimpse of the Pink Terraces in an expedition mounted by GNS Science has provided some initial answers.

The Terraces are an iconic part of New Zealand's history since they were buried in the massive volcanic eruption of Mount Tarawera more than 130 years ago. Until recently it was thought they had both been destroyed by the eruption. The level of Lake Rotomahana rose by at least 60 metres and its area increased by about five times, drowning all original landmarks.

A documentary which screened on Prime TV in 2019 brought the mystery of the missing Pink Terraces to life. It showed our scientists deploying a remotely operated vehicle with a video camera into Lake Rotomahana. The camera filmed remnants of what are believed to be the Pink Terraces, about 70 metres below the surface.

TERRACE SHAPES VISIBLE UNDERWATER

This footage provided evidence that the Pink Terraces survived the eruption of 1886. The shape of the Terraces was instantly recognisable, despite silt and volcanic ash having eroded some of the distinctive terrace faces.

Our previous work in Lake Rotomahana focused on what happened when you drowned what was once an on-land geothermal system, not whether the Terraces survived the eruption. This new evidence has prompted the need for further investigation.

It is hoped in the future that GNS Science will send a manned submersible below the surface of Lake Rotomahana to film the Pink Terraces up-close. This will give an idea of just how much of the Terraces survived and how vigorous the geothermal system is today.

The aim of any future expedition would be to investigate both terrace sites because, although we believe the White Terraces were largely destroyed, getting 'eyes on the ground' will provide closure.

The deep and lasting partnerships we have built with iwi, the GEOMAR Helmholtz Center for Ocean Research in Germany and other partners have helped get us to this point.



“GEOMAR and GNS Science have been long-time partners in exploring the oceans with deep submergence technology, including remotely operated vehicles and manned submersibles. The chance to explore the North Island's lakes with the same technology is greatly expanding our understanding of New Zealand's diverse subaqueous habitats and geological environments.”

Dr Mark Hannington, GEOMAR Helmholtz Center for Ocean Research, Kiel, Germany

Wānanga with north Taranaki iwi



Telling stories from different perspectives – scientific and Māori – provides GNS Science with a much greater appreciation of fundamental issues facing our communities.

Our long association with north Taranaki iwi through geological fieldwork resulted in a three-day Te Kura Whenua wānanga (Earth science knowledge-sharing workshop) with two local iwi in March 2019. The wānanga was held at the Pukearuhe Marae with Ngāti Tama and Ngāti Mutunga.

Over the years we have held several wānanga around New Zealand as a way of building relationships with iwi and giving back to communities who have supported our research efforts.

Young and old from both iwi attended this wānanga alongside GNS Science staff and interns. It provided an opportunity to kōrero with local iwi, discuss insights regarding the whakapapa of their rohe (local area), and address questions about geological formations.

We tailored the activities to local interest in seabed mining, characteristics of iron sands, coastal erosion and sea level rise, as well as the geology of the local Mount Messenger and Urenui formations.

There was a lot of positive feedback from this event which has reinforced our view of the importance of this work.

Delving into a submarine volcano

GNS Science has led research on an active submarine volcano northeast of White Island, which may help the world find more clean-tech minerals such as copper as we move towards a low-carbon society.

In a technically challenging operation, scientists drilled into the submarine Brothers volcano to find out about its internal workings, particularly how metals are transported from its interior to the seafloor.

For some decades, scientists have been unsure of the exact mechanism that results in metal-rich deposits forming on the seafloor at submarine volcanoes. The drilling and subsequent research, undertaken as part of our membership of the International Ocean Discovery Program with Australia, revealed a two-stage process deep inside the volcano near its magma body.

From inside hydrothermally active submarine volcanoes, hot metal-rich brines at 320°C are formed from fluids derived from the magma and then find their way to the sea floor. There they mix with seawater at about 4°C, triggering the metals to precipitate out. They form the metal-rich black-smoker chimneys that are familiar at Brothers and other seafloor hydrothermal systems. Some of the chimneys at Brothers are 20 metres high and are rich in metals such as copper, zinc and gold.



We believe the finding will have international significance as it could help identify new deposits of clean-tech minerals on land. Many of these deposits originally formed on the seafloor, but have since been uplifted through tectonic processes.

Various metals are considered crucial to help the transition to a low-carbon world. The push for more electric vehicles, solar panels and wind turbines will require enormous amounts of critical metals, including copper.

“Researchers from GNS Science were key in providing the scientific data and expertise on seafloor mineral deposits, necessary to provide a compelling case for securing a drilling expedition to the Brothers submarine volcano in the highly competitive International Ocean Discovery Program.”

**Dr Susan Humphris, Senior Scientist,
Woods Hole Oceanographic Institution,
Massachusetts, USA**



Reviving land and water resources for tangata whenua

GNS Science and local iwi are partnering in two new land and water restoration projects. One project is aiming to rehabilitate land impacted by geothermal development near Reporoa in the Rotorua district, and the other will improve land and water quality around Hokianga Harbour in Northland.

Our scientists will work with Tāhorakuri A1 Section 30 Trust to improve land near Reporoa that has suffered from subsidence, loss of geothermal surface features, and westward migration of the Waikato River.

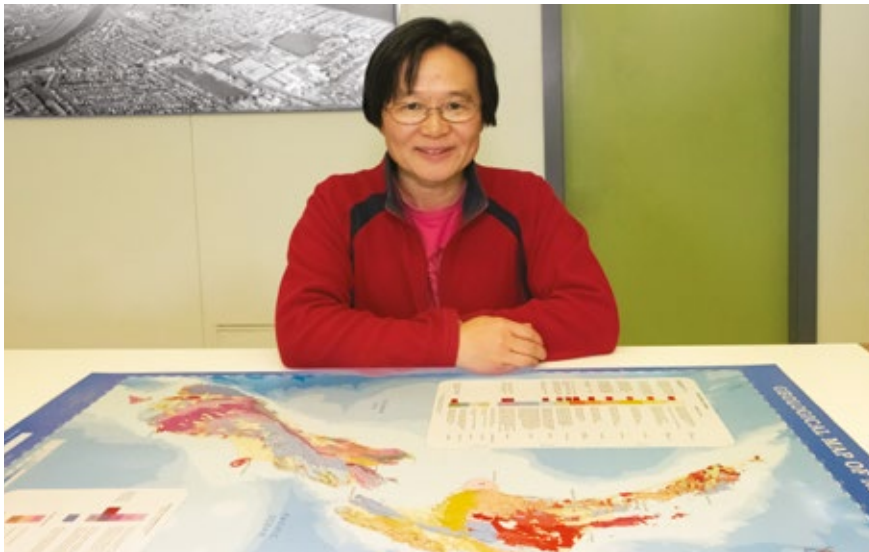
A key part of the project is developing a model which combines geoscience with mātauranga-a-hapū. It will combine geothermal, freshwater and cultural resources with economic opportunities

which are based on collaboration between hapū and geothermal field operators.

In Northland, GNS Science staff will work with Far North iwi Te Rarawa Anga Mua to build their capacity to manage and restore parts of Hokianga-Nui-a-Kupe (Hokianga Harbour). Human activity has resulted in species loss, poor water quality and damaging siltation.

Twenty-eight marae link to the harbour and its estuaries, and local communities want to restore and regenerate the harbour's mauri (life force). The projects have received funding from the Ministry of Business, Innovation and Employment's Vision Mātauranga Capability Fund — Te Pūnaha Hihiko.





Geological map gets better and better

“The utility and accessibility of the QMAP seamless GIS dataset means it is being integrated into many recent geoscience applications. This includes a national shallow shear wave velocity model spearheaded by the University of Canterbury, and international geoscience data-sharing platforms for industry and science.”

**Dr Mark Rattenbury, Programme Leader,
GNS Science**

The development of the New Zealand landmass we see today occurred over many hundreds of millions of years. And yet we regularly need to update our geological maps to reflect the changes happening now and our increased understanding as science moves forward.

This past year we updated the 1:250,000 scale Geological Map of New Zealand to take account of changes since the initial 2014 edition was produced. A wealth of data acquired after the November 2016 Kaikōura earthquake was one of many additions and improvements made to the map, providing a greater level of detail overall.

The map, also known as QMAP for quarter-million scale, is one of the most used of GNS Science’s digital geological map products. Last year it had 53,000 online views through a webmap application. It forms one part of the Nationally Significant Collections and Databases maintained by GNS Science.

The substantially updated version features 15 different layers of geological information that can be displayed on screen by the user in any number of chosen combinations.

These layers have rich information relating to geological units, faults, fold axes, landslides, and geological resources such as mines and quarries.

The map is used by a wide range of sectors including insurance, education, scientists, infrastructure providers, tourism, government and the public. It is available for purchase, download and viewing online.

Updating the map draws on geological knowledge gathered by teams across GNS Science, as well as information from universities and industry.

An upcoming addition will include the Chatham Islands and integration of other work in the wider geological map portfolio. This work includes urban geology and regional projects on volcanoes and areas with economic concentrations of clean-tech minerals used in low emissions technology.



UNLOCKING THE SECRETS OF THE HIKURANGI SUBDUCTION ZONE

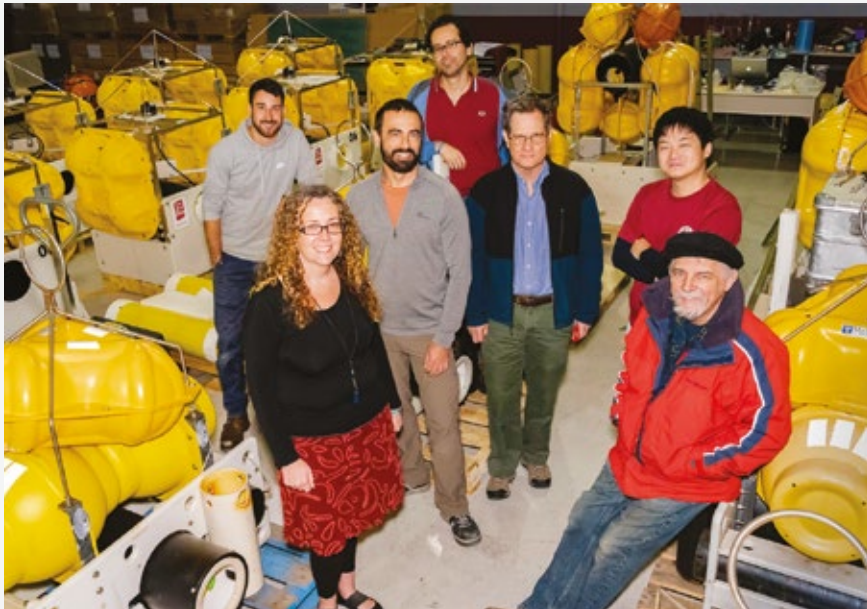
New Zealand's largest and most active fault — the Hikurangi subduction zone — continues to be intensively researched to reveal the history of past earthquakes and modern-day fault slip behaviour. This zone is where the Pacific tectonic plate dives beneath the Australian plate, and it can produce our largest earthquakes and tsunamis.

GNS Science is leading several exciting projects looking at both the historical and present behaviour of the subduction zone. What we learn will help us understand and prepare for the next big earthquake.

Much of this research is part of a five-year, \$6 million MBIE-funded Endeavour project led by GNS Science, with major collaborations and contributions from national and international partners. It includes both onshore and offshore investigations.

PAST EARTHQUAKES

This year our scientists partnered with other science organisations to compile geological evidence of 10 possible subduction quakes on the North Island's east coast in the past 7,000 years. We used evidence of uplifted terraces, coastal subsidence, and deposits from tsunamis at 22 locations



> You can watch a three-minute Youtube animation on the Hikurangi subduction zone at this link:
<https://bit.ly/slowslip>

along the east coast and Marlborough. Although considerable progress has been made toward understanding the seismic and tsunami potential of the Hikurangi subduction margin, gaps remain, and we are trying to fill them.

IMAGING THE SUBDUCTION ZONE

Onshore, our scientists placed 600 seismic instruments across the Raukumara Peninsula on the east coast, in a collaboration with scientists from the United States and Victoria University of Wellington. These devices recorded seismic waves within the top 20-30km of the Earth's crust. Thousands of kilometres of seismic images have also been acquired of the offshore Hikurangi subduction zone.

All this information will help us build a 3D image of the subduction fault below the east coast. This will

provide more understanding about the physical processes that control where earthquakes and slow-slip events occur.

MONITORING UNDER THE SEA

Offshore, we have been looking at the modern-day fault slip behaviour of the plate boundary. About 30 monitoring instruments were deployed under the sea off the coast of Gisborne, Hawke's Bay and Wairarapa in October 2018. These instruments can detect 'slow motion earthquakes' offshore where slippage occurs across the fault, lasting weeks to months, rather than suddenly as in a typical earthquake.

These frequent, large slow-motion events provide a window on how the plate boundary fault zone might behave in a large earthquake. A published study, led by our scientists, provided the first direct physical evidence of the way stresses

change before, during and after slow-slip events. This study might provide a way forward in forecasting future large earthquakes.

In February 2019 we installed further seafloor instruments and downloaded data from earthquake borehole observatories installed beneath the seafloor in 2018. These instruments are giving us an unprecedented near-field view of what happens in the Earth's crust during a slow-slip event.

Findings from all this ongoing work on the Hikurangi subduction zone will help planners and emergency response agencies be better prepared for large earthquakes and tsunamis in New Zealand.

Science Achievements

2018-19 Statement of Corporate Intent Measures of Success

Core Science Area

SCIENCE FOR A SAFER NZ

Impact area	Impacts and measures of success	Progress/Achievement
Hazard Monitoring Relates mainly to SCP Outcome 2: Increase New Zealand's resilience to natural hazards and reduce risk from earthquakes, volcanoes, landslides and tsunamis	<p>Effective response to hazard events: SCI Impact 4</p> <p>Timely response to hazard events: SCI Impact 5</p> <p>Measure of success: By June 2019, GeoNet has a 24/7 awake monitoring service in place, including enhanced capability to respond to local source tsunamis.</p>	<p>In December 2018, the new National Geohazards Monitoring Centre Te Puna Mōrearea i te Rū was officially opened by Hon Dr Megan Woods, Minister of Research, Science and Innovation, and Hon Kris Faafoi, Civil Defence Minister. The new Centre, which is staffed 24/7, enables GNS to provide more timely and accurate advice on all major geological threats to New Zealand (tsunami, earthquake, landslide and volcano). It will enhance the speed of detecting and assessing threats and providing fit-for-purpose advice to natural hazard management response agencies.</p> <p>The facility is located on our campus in Lower Hutt, with a back-up facility at our Wairakei site and at GeoScience Australia. We have successfully tested 'failing over' to these back-up facilities.</p> <p>Our tsunami scientists have developed a database of more than 700 tsunami scenarios and maps that can be used for tsunami warning purposes for New Zealand. The database consists of modelled seafloor earthquakes in subduction zones right around the Pacific Rim capable of producing a tsunami of one metre or greater at the New Zealand coast.</p> <p>When an earthquake occurs in a subduction zone around the Pacific, the nearest scenario in the database can be called up to provide an early estimate of the height of a tsunami and arrival time at the New Zealand coast. As more detail on the size, depth, location and mechanism of an earthquake becomes available, the initial estimate can be refined to provide a more accurate threat assessment of an incoming tsunami.</p> <p>In the past year we have more than doubled the number of pre-calculated scenarios and added more detail, so they are more useful to responding agencies.</p>
Understanding Hazards Relates mainly to SCP Outcome 2: Increase New Zealand's resilience to natural hazards and reduce risk from earthquakes, volcanoes, landslides and tsunamis	<p>Better mitigation planning: SCI Impact 6</p> <p>Enhanced global research presence: SCI Impact 7</p> <p>Measure of success: By June 2019, a global volcanic impacts database hosted by GNS Science is being operated, in collaboration with the US Geological Survey and the Global Volcano Model.</p>	<p>The groundwork for this project has been completed. The structure of the underpinning database has been agreed with our partners and is under development in partnership with the University of Canterbury.</p> <p>GNS Science has worked with the US Geological Survey and other global stakeholders to agree how the data should be structured and stored into the future. The aim is to have a single, well-curated database with good searchability and ease of use. It also needs to integrate with the NZ Volcano Database and Global Volcano Model and has a public facing component.</p> <p>Metadata have been developed from existing data to match the new structure, and migration to the GNS Science hosted database is underway.</p> <p>The public-facing component is hosted by US Geological Survey (https://volcanoes.usgs.gov/volcanic_ash/) and was updated this year by GNS Science in response to both the Hawaii and Vanuatu eruption crises.</p>

<p>Societal and Economic Resilience</p> <p>Relates mainly to SCP Outcome 2: Increase New Zealand's resilience to natural hazards and reduce risk from earthquakes, volcanoes, landslides and tsunamis</p>	<p>Better-informed policy development: SCI Impact 10</p> <p>Enhanced preparedness, response and recovery: SCI Impact 11</p> <p>Measure of success: By June 2019, research findings on societal resilience have become a key part of MCDEM's new strategy.</p>	<p>The National Disaster Resilience Strategy came into effect on 10 April 2019. It outlines the vision and long-term goals for civil defence emergency management in New Zealand, and the objectives to be pursued to meet those goals. It sets out what we expect in respect of a resilient New Zealand, and what we want to achieve over the next 10 years.</p> <p>Research by GNS Science has directly informed the Strategy, particularly our work in enabling, empowering and supporting community resilience. Iwi management plans have also received specific mention in the draft MCDEM Risk Assessment Guidance for CDEM Group Planning. This is a direct result of GNS Science research into the value of these plans for emergency management.</p> <p>Feedback on our contribution and inputs from the many agencies involved in disaster resilience in New Zealand has been positive, with MCDEM and others welcoming the Strategy's use of our science as a core development principle.</p>
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Core Science Area

SCIENCE FOR A MORE PROSPEROUS NZ

Impact area	Impacts and measures of success	Progress/Achievement
<p>Renewable Geothermal Energy</p> <p>Relates to SCP Outcome 1: Increase resource security and economic benefit from the development and diversification of New Zealand's oil and gas, geothermal energy and minerals industries</p>	<p>Enhanced operational efficiency: SCI Impact 13</p> <p>Measure of success: By June 2019, New Zealand geothermal reservoir models are being built using a new flow simulator and validated using a suite of enhanced modelling tools.</p>	<p>We developed reservoir models of the Wairakei, Rotorua and Ngāwhā geothermal systems using the new reservoir flow simulator "Waiwera". By using multiple computers in conjunction with our simulator we can speed up simulations by up to 50 times. This can speed up the time-consuming model development phase where hundreds of model runs are usually required when undertaking model parameter estimation. Another benefit is that it enables the development of models with larger numbers of model elements. This allows small scale features such as faults and significant fractures to be represented more realistically. As a consequence, we expect these models will offer more reliable predictions of the future response to production and injection of fluids.</p>

UNDERPINNING GEOSCIENCE KNOWLEDGE

Impact area	Impacts and measures of success	Progress/Achievement
<p>Zealandia Revealed</p> <p>Relates to SCP Outcomes 1, 2 and 5</p>	<p>Deeper understanding of crustal evolution: SCI Impact 18</p> <p>Deeper understanding of Earth deformation and plate boundary processes: SCI Impact 19</p> <p>Measure of success: By June 2019, IODP drilling of the Hikurangi subduction zone, the Tasman Sea, and Brothers Volcano, is providing high quality samples and data for analysis, and new and important insights.</p>	<p>With our national and international partners, we continue to intensively investigate New Zealand's largest and most active fault – the Hikurangi subduction zone, which lies to the east of the North Island. The aim is to better understand the history of past earthquakes and modern-day fault slip behaviour.</p> <p>What we learn will help us prepare for the next big earthquake on this fault. This year our scientists partnered with other science organisations to compile geological evidence of ten possible subduction quakes on the North Island's east coast in the past 7000 years. We used evidence of uplifted terraces, coastal subsidence, and deposits from tsunamis at 22 locations along the east coast and Marlborough.</p> <p>In another initiative, our scientists placed 600 seismic instruments across the Raukumara Peninsula on the east coast, in a collaboration with scientists from the United States and Victoria University of Wellington. These devices record seismic waves within the top 20-30km of the Earth's crust. Thousands of kilometres of seismic images have also been acquired of the offshore Hikurangi subduction zone. All this information will help us build a 3D image of the subduction fault below the east coast. This will provide improved understanding about the physical processes that control where earthquakes and slow-slip events occur.</p> <p>Offshore, we have been looking at the modern-day fault slip behaviour of the plate boundary, with monitoring instruments deployed on the seafloor off the coast of Gisborne, Hawke's Bay and Wairarapa this year. These instruments can detect 'slow motion earthquakes' offshore where slippage occurs across the fault, lasting weeks to months, rather than suddenly as in a typical earthquake. These slow-motion events provide a window on how the plate boundary fault zone might behave in a large earthquake. A published study, led by our scientists, provided the first direct physical evidence of the way stresses change before, during and after slow-slip events.</p> <p>Three-dimensional seafloor models of Brothers submarine volcano have been integrated into the GNS Science-run GeoTrips webpage. These appear as virtual GeoTrips, which give the public a new way of exploring underwater Zealandia features. Brothers submarine volcano is the most hydrothermally active seafloor volcano in the world.</p> <p>A GNS-led paper for IODP Expedition 376 to Brothers volcano was published in <i>Geology</i> and featured in the NZ media. www.stuff.co.nz/science/113896909/as-copper-supplies-get-tight-kiwi-scientists-work-out-how-its-deposited-on-the-seafloor</p> <p>The Proceedings of IODP Expedition 376 are now published on the IODP website (http://publications.iodp.org/proceedings/376/376title.html).</p>
<p>Geoscience Information</p> <p>Related to SCP Outcomes 1, 2, 3 and 5</p>	<p>Enhanced database efficiency: SCI Impact 20</p> <p>Measure of success: By June 2019, a Data Management Strategy and Roadmap is in place for our eight Nationally Significant Databases and Collections, and all are being managed to those expectations.</p>	<p>GNS Science has custodianship of eight high-value Nationally Significant Collections and Databases (NSCDs) covering geological maps, rocks, fossils, groundwater, earthquakes, geomagnetism, and volcanism, all managed under a SSIF Infrastructure research programme. In accordance with GNS Science's overarching Data Management Strategy, these datasets have Data Management Plans, Risk Registers and Dataset Procedures compiled for each of the NSCDs and Data Quality Control Plans are well advanced. These collectively define the operational and strategic data framework for the NSCDs. We have drafted a data management roadmap for GNS Science's NSCDs and other scientific collections and databases. Full implementation of the roadmap is dependent on the outcome of the current MBIE review of Scientific Collections and Databases and future funding support for GNS Science's Scientific Collections and Databases.</p>



OUR PEOPLE



GNS SCIENCE 2019 EXCELLENCE AWARD WINNERS



CÉCILE MASSIOT

Excellence in Early Career Achievement

'Working in topics so relevant to society is motivating. At GNS Science, I particularly enjoy exchanging ideas with the multi-disciplinary experts, to link together the many facets of Earth systems.'

Cécile is a structural geologist who graduated in 2017 with a PhD and is making a significant science contribution in both public-good research and commercial work. She has already published more than 15 scientific papers internationally and is playing a pivotal role in leading new science projects, including drilling a scientific borehole in the Taupō Volcanic Zone. She is a thought-leader, using her passion for science to inspire other researchers and engage with the public.



DAN DOOLEY

Excellence in Working Together

'I can't imagine many other jobs that could give me as many opportunities as working at GNS Science. Every project has me working on something new and interacting with other teams across a vast spectrum of expertise. This constantly challenges me to improve my own skills to deliver excellent products.'

In his work as a GeoNet Lead Developer, Dan demonstrates exemplary teamwork with teams across GNS Science, exceeding what is required in his role. He volunteered to help set up the Early Career Staff Network and has used his outstanding facilitation skills to get engagement across GNS with the IT Applications team, resulting in clear actions for improving processes. He is a great example of the value of sharing knowledge across teams and working together to achieve cultural change.



KATIE JACOBS AND STUART HENRYS

Excellence in Deep Partnering

'It's an honour and a privilege to be able to successfully undertake large and complex field projects and engage local communities in the process. I count those groups now as our friends and look forward to GNS Science growing the relationships.'

Stuart Henrys

'I am very proud of the relationships we established during this complex project. The success of the project speaks to the level of support we received from our colleagues at GNS Science and the willingness of New Zealanders to support scientific research.'

Katie Jacobs

For the past two years Katie and Stuart have led efforts to create successful partnerships as part of the Seismogenesis at Hikurangi Integrated Research Experiment project. This project is investigating earthquake behaviour of tectonic plates beneath the North Island's east coast. This large data acquisition campaign required engagement and deep partnering with a broad range of groups and organisations. Katie and Stuart have established mutually beneficial, long-lasting partnerships with community groups, schools, iwi and local government.

Every year, GNS Science presents awards to celebrate outstanding staff achievements and contributions.

Staff are nominated by their peers and a group of senior staff select the category winners. In 2019, we introduced a new range of awards to reflect our new strategic direction and the diversity of contribution across all of our work, with nearly 40 nominations across six categories.



KYLE BLAND

Excellence in Creating Awareness

'Knowledge is only valuable if it is shared, and we are passionate about actively including the public into our 'public-good science'. Our outreach and educational initiatives are incredibly rewarding to be part of. We get to visit some amazing places, to work with fabulous people, and it's amazing to be part of the "a-ha!" moments when something clicks.'

Kyle, a senior geologist, is a prominent figure in our outreach activities. He has played a key role in starting and leading several high-impact initiatives including GeoCamp, a field-based geoscience course for intermediate school students, and Te Kura Whenua, a marae and field-based iwi community engagement initiative. He also regularly engages with the public through talks and YouTube videos. He is an excellent example of a scientist generating awareness of our work and communicating his knowledge in an accessible way.



SALLY POTTER

Excellence in Creating an Impact

'Working at GNS Science gives us the opportunity to conduct world-class research, and then help to implement the findings to make a difference to New Zealand's communities. I enjoy being able to work collaboratively with scientists from a range of disciplines and institutions, and directly with the users of our early warning systems, to ensure our findings are relevant and useful.'

Sally has made a huge impact in the field of early warning systems. She has produced a significant body of literature as well as becoming internationally recognised in this research area. Her contribution was underlined this year by the Ministry of Civil Defence and Emergency Management using her social science research to develop the messaging for its new emergency mobile alerts for the New Zealand public. This will lead to better responses to these warnings. This project is one of several which Sally has led that have contributed to improvements to New Zealand's warning systems for natural hazards.



SHARRYN DUGGAN

Excellence in Making a Difference

'GNS Science is a great place to work. There is always something new happening and people are always happy to share what they are working on. I like that I can contribute to their work through my role.'

Sharryn is part of the Human Resources team and is recognised for going above and beyond the call of duty to help others with a 'can-do' approach. In her previous role in the Health and Safety team she introduced many successful processes which have been used to benefit the entire organisation. Sharryn works tirelessly to make a difference for her team and for GNS Science as a whole.

OUR PEOPLE & CULTURE



BEING A GOOD EMPLOYER

At GNS Science we believe our people are our strength. We work hard to make sure our organisation is where people want to come to be part of exciting scientific work and belong to an organisation focused on developing a positive and inclusive culture.

Over the past year, we have started a number of initiatives. Many of these are multi-year programmes intended to build on the best of our rich heritage to ensure we are known for our excellent science, and as an excellent employer.

LOOKING AT THE WAY WE WORK

This year we formed a new Culture Working Group to help understand not only what makes us strong as an organisation now, but what we might need to do more of to be successful as we take these strengths into the future and evolve to meet new science challenges.

The new group includes staff from across the organisation and has made great progress defining the values and behaviours we will need to support our culture while also celebrating what is unique and special about GNS Science.

Part of this work has included looking at how we can bring our four new Strategic Pillars to life. The four pillars came out of the Strategic Review and were a summary of what our stakeholders said they were looking to us for. They are:

- Investing for and with purpose
- From decision-taker to decision-maker
- Deep partnering
- Awareness of our work

Our four Strategic Pillars – Investing with Purpose, Deep Partnering, Decision Maker and Awareness – reinforce our culture and values, so that our science is useful, usable and used.



Me āta whakangao, me whakangao hoki mō te whāinga

Investing for and with Purpose

Ko tā tātou e arotahi nei, kia mahi hei whakatutuki i ngā hiahia o Aotearoa

We focus our work on meeting New Zealand's needs



He Kaiwhakatau

Decision maker

Ka whakamahia tā tātou mōhiotanga hei whakaaweawe i ngā whakatau a tō tātou hunga whaipānga

We use our knowledge to influence stakeholder decisions



Kia whai hoa rangapū tūturu nei

Deep Partnering

Ka whai hoa rangapū tātou mō te momoho pūmau

We partner for long-term success



Te Aroā

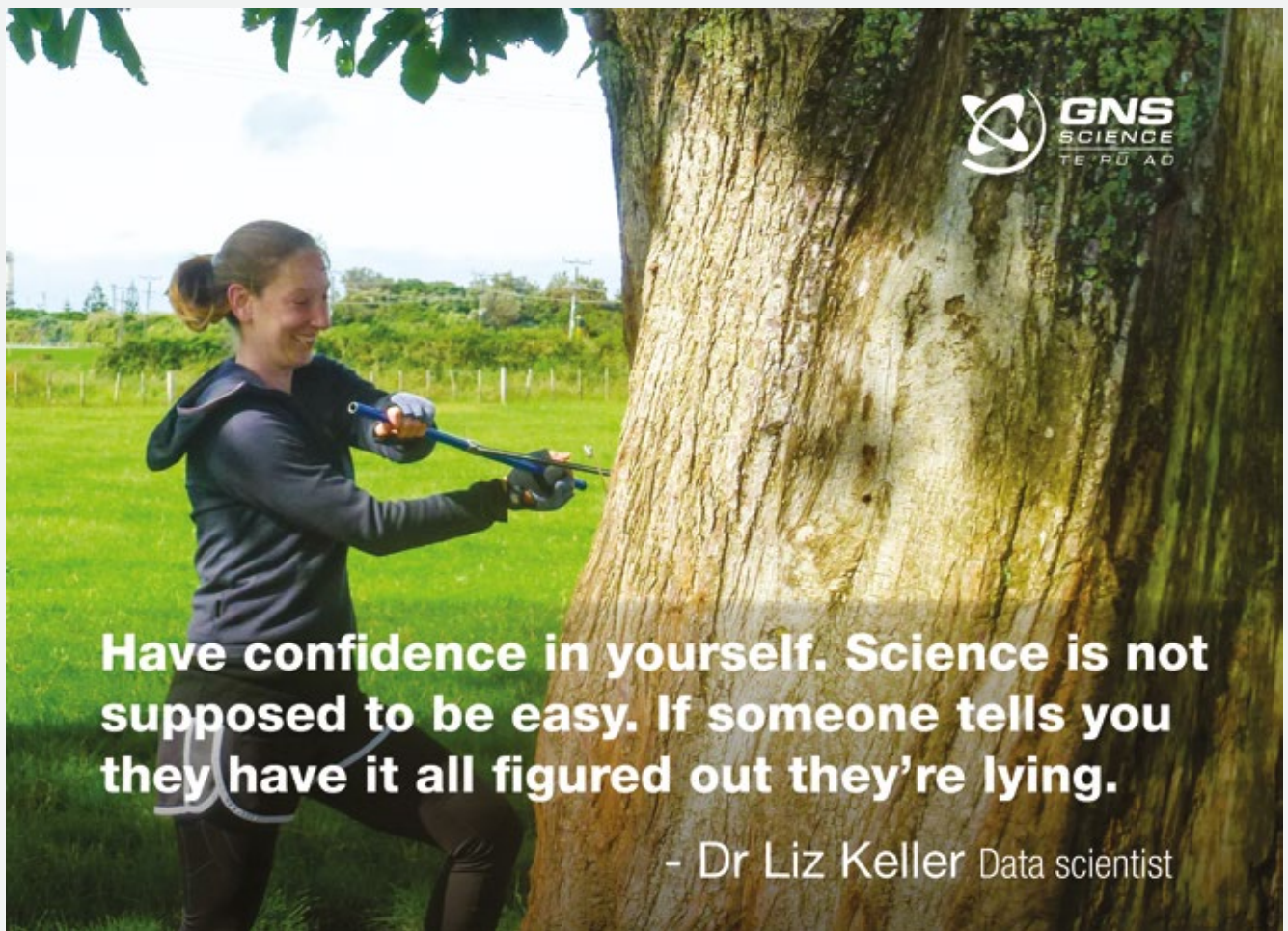
Awareness

Ka para te huarahi kia whakamihia tātou mō ngā mahi pai e oti ana tātou

We build recognition for the great work we do

INTERNATIONAL WOMEN'S DAY

To mark International Women's Day in March 2019, we asked a number of our women scientists what they would tell young women interested in a career in science. We shared their responses on GNS Science's social media as part of our push to see a better gender balance in science. We got a great response with over 13,500 people engaging with our posts. Engineering geologist Sally Dellow said: "Every year I go to places I didn't expect and work with amazing people. What's not to like about that?" Collections manager Marianna Terezow said: "With passion and tenacity, science can open many doors for you and take you on some great adventures."



Examples of the International Women's Day Facebook Campaign



STAFF ENGAGEMENT

We held a staff conference in May 2019 – the first one in about five years. It brought together 420 people from all our sites for two days of workshops, presentations, team building exercises and discussions. It provided an opportunity to mark the implementation of the new science structure around our strategic themes, learn more about GNS Science and the range of work we do across the business.

Following the conference, staff indicated they enjoyed networking with others, had developed a better understanding of the organisation's work, learnt more about our strategy and future priorities, and were excited about GNS Science's future.

We conducted a short 'pulse' survey in April 2019. This was the first engagement survey since 2016. Given it followed our restructure, it provides a baseline measure of engagement as we bed in our new organisational science structure and way of working. The results showed 62% for engagement by staff and 55% for a sense of common purpose. Our goal is 65% engagement at the full engagement survey planned for late 2019.

DEVELOPING SCIENCE CAREERS

An Early Career Staff Network has been set up to bring together staff across the whole organisation in the early stages of their careers. It aims to help build strong working relationships, enhance collaboration and innovation, grow our young professional staff and ensure early career staff are represented in our organisation's strategy.

A new career working party was convened in 2019 to continue work begun in 2017 reviewing the career path profiles, progression and the performance development processes. Initial work was put on hold during the Science Review in 2018. The new working party developed recommendations for changes to the way we think about career progression, performance management and recognition. Following endorsement by the GNS executive team and extensive engagement with staff, the first of the initiatives were rolled out at the beginning of August 2019. Further co-design work with staff will resume in October, in time for implementing the remaining changes by June next year.

EMPOWERING OUR STAFF

Leadership development workshops started in May this year with 47 leaders from across GNS Science attending. These were capability building sessions focussed on career and leadership pathways, building a team and personal resilience for leaders. They were the first step in our Leadership Development Programme which is designed to enhance leadership capability and set clear expectations for our managers to be trusted and capable leaders. Future sessions will focus on coaching and development.

This year we developed a Te Reo Māori programme to support our strategic priority of developing GNS Science's capability and capacity to support Vision Mātauranga and our relationships with iwi/Māori. The training covers fundamental Te Reo to help our staff develop confidence to use Māori in everyday conversation. Staff interest in participating has been overwhelming.



KEEPING OUR PEOPLE SAFE

We want the safety, health and wellbeing of all our staff to be top of mind for everyone at GNS Science. This means proactively looking to improve our safety performance, not just a culture of compliance — this proactive approach was confirmed in a December 2018 Safety Plus Assessment.

Over the past year, against a target of 95%, we achieved a 97% check in/check out for people going into the field. We've made it as easy as possible for people to do this either via text or an online portal. The high rate of participation gives us great confidence we know where our people are when they are out and about.

Our Avalon site is trialling a new coloured card initiative designed to make it easy to acknowledge positive safety behaviour and report potential risks as they are spotted. So far, the trial has been well received, so we are hoping to roll it out to our other sites in the coming year.

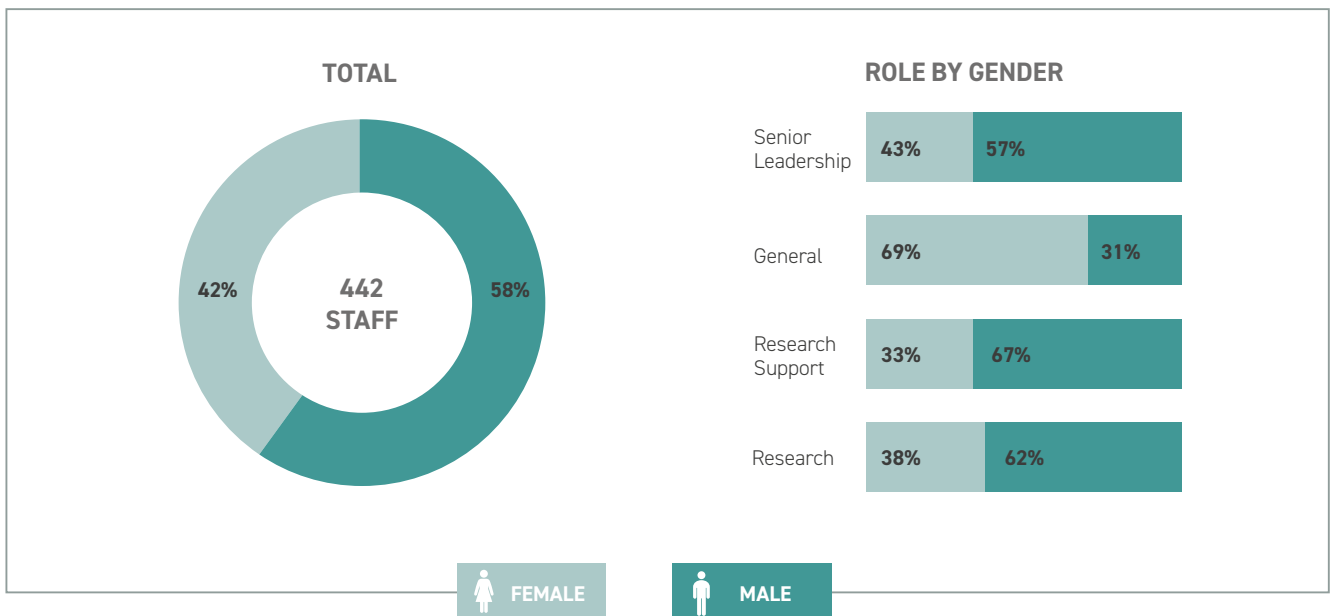
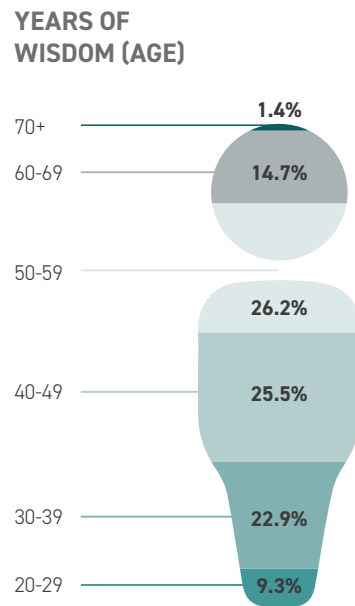
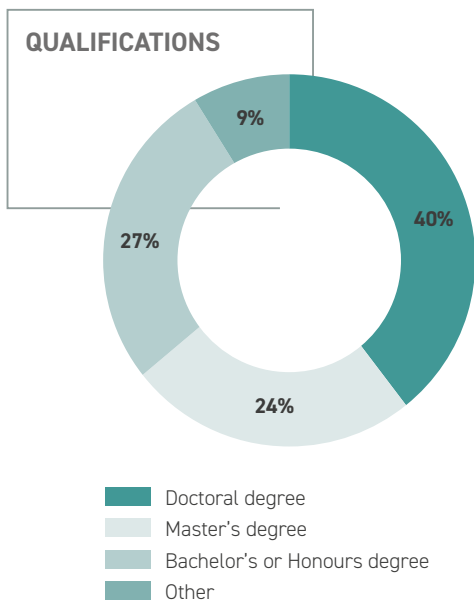
While physical safety is crucial, we also take mental wellness very seriously too. In fact, we are recruiting for members to form a Wellness Committee. The committee will look at both the mental and physical wellbeing of our people. This complements the onsite visiting counsellors available for one-on-one help, the existing 24/7 0800 number where staff can access counsellors from anywhere in the country on a wide range of topics, and the provision of workshops on resilience and mental wellbeing.

The new Wellness Committees will sit alongside our well-established health and safety site committees made up of staff members and which operate at each of our sites to help with risk management. They give us insights into how we can be safer at work and help develop our annual proactive health and safety goals. These committees also develop their own initiatives which help GNS meet our goals to manage our critical risks and improve our Health and Safety culture. This year

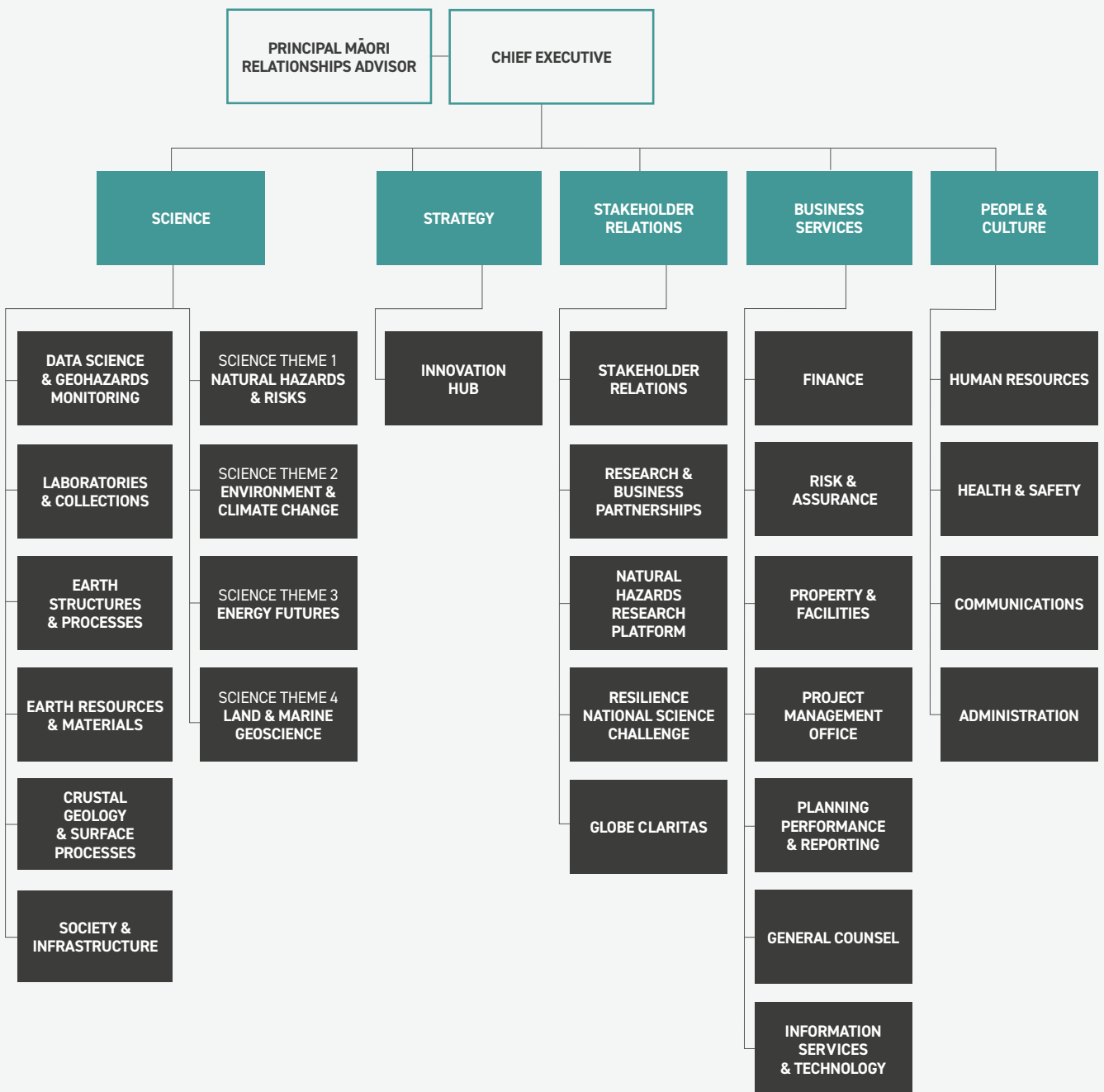
we have reviewed our health and safety policy through our site committees. The committees also workshopped ideas for risk-based health and safety indicators to help team leaders in developing their health and safety business plans.

We have broadened our policy and procedure around the use of alcohol to include managing the risks of drugs and alcohol in the workplace.

OUR PEOPLE AT A GLANCE



OUR ORGANISATION



OUR BOARD OF DIRECTORS



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

DR NICOLA CRAUFORD

CHAIRMAN

BSc (Hons), PhD, FEngNZ, CPEng,
FAICD, CFIInstD

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 New Zealand and the United Kingdom. She is currently a director of the Environmental Protection Authority, Watercare Services Ltd, and Orion New Zealand Ltd.

SARAH HAYDON

DEPUTY CHAIRMAN

BSc, FCA, CMIInstD

Auckland

(Appointed 1 July 2014)

Sarah is a director of Ports of Auckland Limited, Deputy Chairman of The Co-operative Bank Limited and Chair of New Zealand Riding for the Disabled Association Inc. 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, CMIInstD

Hamilton

(Appointed 1 September 2016)

John has held a number of executive leadership and director roles in early-to-mid-stage technology companies in 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), CMIInstD

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 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 in major hazard facilities. 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 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 Chairman of Te Rarawa Farming Ltd. 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 at 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. Prior to his time at EQC Ian spent four years at the Accident Compensation Corporation where he was responsible for the management of financial resources and the returns of ACC's NZ\$11 billion global investment fund. ACC was Ian's first job in New Zealand. He was born and grew up in the north of England. After graduating from Manchester University, he worked for BP in London and Melbourne for eight years before joining Diageo PLC where he held a range of corporate finance roles in both the UK and Europe.

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.

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 also held senior management roles at the Foundation for Research, Science & Technology, AgResearch, and Opus International.

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 iwi, government agencies, and industry. Having previously worked at the Foundation for Research, Science & 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 and the Ministry for the Environment.



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

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 The 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 New Zealand. Gary is currently 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.

TANIA GERRARD

PRINCIPAL MĀORI
RELATIONSHIPS ADVISOR

Te Whānau 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 leading Vision Mātauranga activities across the organisation.

ANDREW SIMPSON

INTERIM 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 the University of Waikato. At GNS Science, Andrew is responsible for leading a wide range of support functions including finance, legal, risk and assurance, ICT, property and facilities, project management office and performance and reporting services.

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.



DAVID MIDDLETON
CHAIRMAN

David joined business continuity and risk management company Kestrel in 2010 after 17 years as Chief Executive of the Earthquake Commission. Kestrel works with organisations to improve their readiness, response, and recovery capabilities. David's areas of specialisation are insurance and reinsurance, disaster recovery planning and the financial aspects of disaster recovery, public policy and research administration. He also has a wide knowledge of natural disaster schemes implemented in other countries.

David is a Fellow of the Chartered Insurance Institute and of the Australian and New Zealand Institute of Insurance and Finance, and has an MBA with Distinction from Victoria University of Wellington. He is an Honorary Fellow of Engineering New Zealand, has Honorary Membership of the Wellington Lifelines Group and Lifetime Membership of the New Zealand Society for Earthquake Engineering. In 2010 David became an Officer of the New Zealand Order of Merit.



DR CHRIS PIGRAM

Chris is a geologist with more than 40 years' experience in geological research and he has led Geoscience Australia's marine & petroleum geoscience, minerals geoscience, and geospatial & earth monitoring programmes. He held the position of Chief Executive Officer of Geoscience Australia between June 2010 and February 2017. He has authored or co-authored more than 100 publications covering tectonics, petroleum, basin analysis, and marine geoscience.

Chris is a member of the Commonwealth Scientific and Industrial Research Organization's Deep Earth Imaging Advisory Panel, Chairman of AuScope Limited, and Chair of the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal, Chair of MinEx Cooperative Research Centre, and a Member of the Australian Space Agency Advisory Group.



PROFESSOR BRENT MCINNES

Brent is a Research Professor at Curtin University and Director of the John De Laeter Centre in Perth, Western Australia. Previous to this he was employed as a Chief Research Scientist in the Division of Earth Sciences and Resource Engineering of the Commonwealth Scientific and Industrial Research Organization (CSIRO). Educated in Canada and at the California Institute of Technology, he has 28 years of international experience in the geoscience

and resources research sector. He has led multiple public-private partnership projects with companies, including Australian Scientific Investments, BHP-Billiton, Barrick, Chevron, INCO, Rio Tinto, and Sinopec.



DR ANNA DE RAADT

Anna is Team Leader of the Better Buildings Research group at the Building Research Association of New Zealand (BRANZ). She was formerly the Director of the Cooperative Research Centre for Spatial Information (CRCSI) based in Land Information New Zealand. Prior to this, she was a Senior Sector Manager for Manufacturing and Resources, Science Investments at the Ministry of Business, Innovation and Employment.

Anna originally hails from an academic background as an Associate Professor of Organic Chemistry at the Technical University of Graz, Austria. She brings a breadth and depth of knowledge and experience across government, industry, and research sectors. In a number of her roles, she has facilitated commercialisation of science and also demand-driven research.



DR MAC BEGGS

Mac has 40 years' experience as a petroleum exploration geologist in New Zealand, and internationally. He was Group Manager Resources with GNS Science in the 1990s and a petroleum geologist with its predecessor the Department of Scientific and Industrial Research. He was founder and Managing Director of exploration geoscience company GeoSphere Ltd, and served

as General Manager of Exploration at New Zealand Oil & Gas Ltd between 2009 and 2016. Mac is an Adjunct Professor at University of Canterbury and undertakes research and consultancy projects on a part-time basis.



MIKE ALLEN

Mike has a background in engineering and more than 35 years in the geothermal energy industry, undertaking project developments in Asia, Africa, Latin America, and the Mediterranean. In 2012, he was appointed Special Envoy for Renewable Energy on behalf of the Ministry of Foreign Affairs and Trade. He is a director of the Singapore-based ReEx Capital Asia set up in 2006 to provide a bridge between clean energy projects and investors in Southeast Asia. Mike is Executive Director of Geothermal New Zealand Inc,

which promotes export opportunities in international geothermal markets. Between 2009 and 2016 he was a member of the Board of Mercury Energy (formerly Mighty River Power).



EMERITUS PROFESSOR LIONEL CARTER

Lionel is Emeritus Professor of Marine Geology at Victoria University of Wellington. He trained in geology and oceanography at the universities of Auckland and British Columbia, Canada, and has undertaken research in the North Atlantic, Pacific and Southern oceans. He jointly led New Zealand contributions to major international projects including Leg 181 of the Ocean Drilling Program and the MARGINS "Source to Sink" initiative.

He has applied expertise gained from marine geological and paleo-environmental research to ocean engineering projects. Currently, Lionel's focus is on geohazard protection of the submarine fibre-optic cable network that underpins global communications and the internet.



OUR NUMBERS

PERFORMANCE INDICATORS

For the year ended 30 June 2019

Non-Financial Indicators

Indicator	Measure	Actual 2019	Target 2019
Impact			
Research delivery	Research milestones (critical steps) on track or completed	85%	>85%
Impact case studies	Impact case studies published	3	3
Science excellence			
Peer-review	Programme reviews carried out	6	5
Publication impact	Impact of scientific publications (weighted citation index)	3.62	3
Joint publications ¹	Papers co-authored	86%	90%
Research leverage			
Discovery science	Proportion of (basic) science investment (new ideas generation)	30%	30%
Co-funding ²	Revenue per FTE from commercial sources (\$000s)	73	69
Consultancy	Commercial reports per scientist FTE	1.34	1
Vision Mātauranga			
Māori engagement	Projects with Māori stakeholders embedded in the research	8	4
High performance culture			
Health and Safety	Recordable injuries per 200,000 work hours (rolling 12-month average)	1.7	<3
Financial indicator	Revenue per FTE (\$000s)	226	220

¹ Analysis of past performance shows that the average number of co-authored papers over the last nine years was 83%.

² This KPI was changed from commercial revenue per scientist PTE (Target 80) from quarter two.

Note: Additional indicators relating to priority setting, team selection, knowledge transfer and staff engagement are measured on a two-yearly basis and will be reported in the 2019-20 year.

Financial Performance Indicators

	Actual 2019	Budget 2019	Actual 2018
Revenue			
Revenue (\$000) ¹	95,314	94,414	88,544
Revenue growth	8%	7.5%	2%
Operating results (\$000)			
Operating expenses (including depreciation and amortisation) ²	94,926	92,253	89,832
Profit before interest, tax, depreciation and amortisation (EBITDA)	5,897	8,161	5,295
Profit/(loss) before interest and tax (EBIT)	388	2,161	(1,671)
Profit before tax	1,026	2,701	(1,032)
Profit after tax	455	1,945	(773)
EBITDA per FTE	14	20	14
Total assets	59,226	60,476	61,272
Total equity	34,564	35,706	34,109
Capital expenditure ³	4,192	7,350	4,009
Liquidity			
Quick ratio	2.20	2.3	2.11
Profitability			
Return on equity	1.3%	5.6%	(2.3%)
Operating margin	6.2%	8.6%	6.0%
Operational risk			
Profit volatility	29.3%	25%	22.4%
Forecasting risk	(2.8%)	(1.4%)	(2.5%)
Growth/Investment			
Capital renewal (before impairment adjustments)	76%	123%	72%
Financial strength			
Equity ratio	58%	59%	56%

¹ Revenue – includes significant new funding from MBIE for the fit-out and operation of the National Geohazards Monitoring Centre, increased research revenue from greater collaboration with other Crown Research Institutes and government agencies, and increases in overseas commercial work.

² Operating expenditure (including depreciation and amortisation) – increased largely due to an increase of 46 full-time equivalent staff reflecting additional staff required for the new National Geohazards Monitoring Centre and additional roles created under the new organisation structure.

³ Capital expenditure – lower than budget predominantly due to a large information technology data storage project being delayed until FY2019-20.

CORPORATE GOVERNANCE

OVERVIEW

The Board is committed to ensuring that the Company and its subsidiaries maintain the highest standards of corporate governance, ethics, corporate behaviour and accountability. The basis for these is set out in the Board's Charter and in the policies and procedures established and maintained by the Company.

ROLE OF THE BOARD AND MANAGEMENT

The Board is responsible to the shareholding Ministers (the Minister of Finance and the Minister of Research, Science and Innovation who is also the Responsible Minister) for governing, directing and controlling the activities of the Company. This includes:

- setting the Company's strategic direction and agreeing the goals in line with the Statement of Core Purpose and annual Statement of Corporate Intent
- overseeing the Company's operation and monitoring management performance against plans to ensure GNS Science is achieving the agreed goals
- ensuring there is an appropriate policy framework and approving key policies
- setting the Company's risk tolerance and ensuring that effective risk management and regulatory compliance policies and procedures are in place
- setting the direction for health and safety management and ensuring that it is achieved.

The Board delegates management of the day-to-day affairs and responsibilities of the Company to the Chief Executive. The Chief Executive leads the Executive Leadership Team whose role is to implement the strategies and plans for achieving the Company's objectives. A formal Delegated and Financial Authorities Policy sets the operational and expenditure delegations within which the Chief Executive and the Executive Leadership Team operate.

APPOINTMENT OF DIRECTORS AND COMPOSITION OF THE BOARD

Under the Company's Constitution, the Board can comprise up to nine non-executive Directors. The Directors, Chairman and Deputy Chairman are appointed by Cabinet on the recommendation of the Responsible Minister.

The term is generally for three years with reappointment for further terms at the discretion of the shareholders. During the year, the Board consisted of seven Directors, which has subsequently reduced to six. The Board considers that it has an appropriate mix of skills, experience and independence to ensure that the Company is governed in a manner that guarantees the interests of shareholders are represented and protected.

On appointment, Directors receive guidelines on the shareholders' expectations, which are in addition to the requirements of the Companies Act 1993. They have access to online resources that contain key information and documents about the Company, its subsidiaries and their operations. New Directors also have the benefit of an induction programme to provide them with an understanding of the Company's business and the markets in which it operates.

Each Director has the right, with the prior approval of the Board, to seek independent legal and other professional advice at the Company's expense concerning any aspect of the Company's operations or undertakings to assist in fulfilling their duties and responsibilities as Directors.

DIRECTORS' MEETINGS

The Board had 11 meetings during the year ended 30 June 2019 including a meeting dedicated to consideration of the Company's strategic direction. There was a programme of site visits and presentations to the Board by the Executive Leadership Team, management and science staff, and regular interaction with key stakeholders which enabled Directors to keep abreast of key aspects of the Company's activities.

OPERATION OF THE BOARD

The Board operates in accordance with the Board Charter. It had four standing committees operating during the year – the Audit and Risk Committee, the People and Culture Committee, the Health, Safety and Environment Committee, and the Science Committee. All committees are operating in accordance with a Terms of Reference approved by the Board. Each committee establishes annual work plans and undertakes an annual review of its Terms of Reference and performance. The table below shows Director attendance at Board meetings and committee member attendance at committee meetings. In addition, any Director may attend any committee meeting.

	Board		Audit and Risk Committee		People and Culture Committee		Health, Safety and Environment Committee		Science Committee	
	No.	No. Attended	No.	No. Attended	No.	No. Attended	No.	No. Attended	No.	No. Attended
Nicola Crauford	11	10	4	4	4	4	3	3	2	2
Sarah Haydon	11	10	4	4	2	2	-	-	-	-
Chris Bush	11	11	4	4	-	-	3	3	-	-
John Sharpe	11	10	4	4	-	-	-	-	2	2
Steve Weaver	11	8	-	-	4	2	-	-	2	2
Paul White	11	11	-	-	-	-	3	3	-	-
Felicity Evans	11	11	-	-	2	2	-	-	-	-

Matters discussed by the committees were reported back to the subsequent Board meeting and key items were discussed and resolved by the full Board.

BOARD EVALUATION

During the year the Board undertook an evaluation of its performance facilitated by an independent party and provided the results to the Responsible Minister's representatives.

AUDIT AND RISK COMMITTEE

The Audit and Risk Committee supports the Board in fulfilling its responsibilities in relation to financial reporting, external audit, risk management, legislative compliance and internal audit.

PEOPLE AND CULTURE COMMITTEE

The People and Culture Committee supports the Board in fulfilling its responsibilities in relation to remuneration policy and organisational culture, and the recruitment, remuneration and performance of the Chief Executive and senior leadership.

HEALTH, SAFETY AND ENVIRONMENT COMMITTEE

This committee supports the Board in fulfilling its responsibilities relating to health, safety and environment matters. The committee reviews and recommends to the Board targets for health, safety and environment performance. The Board then assesses performance against those targets and seeks assurance that the Company has adequate resources to operate the business safely. The Board reviews serious incidents and audit results, and evaluates responses to ensure the adequacy of management actions.

SCIENCE COMMITTEE

The Science Committee supports the Board in fulfilling its responsibilities on the direction and effectiveness of research activities undertaken by the Company. Two meetings were held during the year in conjunction with a meeting of the Strategic Science and User Advisory Panel, which is a standing advisory panel to the Board. The report of the advisory panel was considered by the Science Committee, discussed by the Board at the Board's strategy session and incorporated into the Strategic Science Investment Fund plans that were developed, discussed and agreed with the Ministry of Business, Innovation and Employment (MBIE) during the year.

INTERNAL AUDIT AND RISK MANAGEMENT

The GNS Science internal audit plan is developed by the Risk and Assurance Manager and outsourced Internal Auditor (KPMG) in consultation with the Audit and Risk Committee and approved by the Board. Quarterly reporting on progress with the internal audit plan and progress with internal and external audit recommendations are presented to the Audit and Risk Committee. The Internal Auditor has access to management and the right to seek information and explanation. The Audit Committee meets quarterly with the Internal Auditor without management present.

GNS Science has an established framework to manage risk to inform strategic and business planning processes, to optimise allocation of resources and to allow the Company to effectively recognise, prioritise and respond to risks. Risks are monitored and assessed and reported quarterly to the Audit and Risk Committee and the Board.

EXTERNAL AUDITORS

GNS Science is committed to ensuring that the external audit provider is able to carry out its functions independently. Our Auditor Independence Policy sets out the framework under which we ensure the independence of the external auditor is maintained at all times both in fact and appearance. This ensures that the audit opinion is highly reliable and credible. The Office of the Auditor-General has appointed Trevor Deed on behalf of Deloitte Limited to perform the statutory audit during the year ended 30 June 2019. Deloitte Limited personnel attended four Audit and Risk Committee meetings during the year.

The external auditor may provide non-audit services where these are approved in advance by the Board as being appropriate. No such services were provided by the external auditor for the year 30 June 2019.

CONFLICTS OF INTEREST

All Directors are required to disclose any conflicts of interest or if they have an interest in any transaction, in which case they may not be entitled to partake in discussions (at the Board's discretion) and will not be entitled to vote in relation to the transaction. To facilitate the disclosure of interests and identification of any actual or perceived conflicts of interest, the Company's Disclosure of Interests Register is reviewed and updated at the start of each Board meeting.

PROVISION OF PROFESSIONAL SERVICES

Except in exceptional circumstances, Directors will not provide professional services to the Company and will only do so with the prior approval of the Responsible Minister. This is to avoid a conflict of interest — actual or perceived.

REPORT OF THE DIRECTORS

For the year ended 30 June 2019

The Directors are pleased to present the audited consolidated financial statements of GNS Science for the year ended 30 June 2019. The financial statements have been prepared in accordance with generally accepted accounting practice in New Zealand and the Financial Reporting Act 1993.

The Auditor-General is the statutory auditor pursuant to section 21 of the Crown Research Institutes Act 1992. The Office of the Auditor-General, pursuant to section 32 of the Public Audit Act 2001, has appointed Trevor Deed on behalf of Deloitte Limited to undertake the audit on its behalf.

PRINCIPAL ACTIVITY

GNS Science's principal activity is to conduct scientific research, consultancy services, and product development in earth sciences and isotope technologies in accordance with the principles for the operation of Crown Research Institutes set out in sections 4 and 5 of the Crown Research Institutes Act 1992.

BOARD CHANGES IN THE YEAR

Felicity Evans was appointed to the Board on 1 July 2018. Steve Weaver retired from the Board on 30 June 2019.

REMUNERATION OF DIRECTORS

Directors' fees are set by the shareholding Ministers annually. Fees paid to Directors for services as a Director, including membership of Board Committees and other expenses, during the year were as follows:

Director	Date commenced	2019 \$	2018 \$
Nicola Crauford	1 July 2015	47,356	47,356
Sarah Haydon	1 July 2014	29,598	29,598
Chris Bush	1 January 2016	23,678	23,678
John Sharpe	1 September 2016	23,678	23,678
Steve Weaver	1 July 2010	23,678	23,678
Paul White	14 August 2017	23,678	20,718
Felicity Evans	1 July 2018	23,678	-

With the exception of Steve Weaver (Director) who received \$13,000 (2018: \$16,000) as the GNS Science appointed Governance Group member for the Resilience to Nature's Challenges, National Science Challenge, no other Director during the year received (nor was entitled to receive) any benefit other than the disclosed Directors' fees.

EMPLOYEE REMUNERATION

In accordance with section 211(1)(g) of the Companies Act 1993, the numbers of employees who received remuneration and other benefits totalling \$100,000 or more, in \$10,000 bands, during the year were:

\$000s	2019	2018
100-110	34	31
110-120	27	28
120-130	23	19
130-140	15	18
140-150	12	14
150-160	11	9
160-170	10	9
170-180	6	6
180-190	4	3
190-200	4	1
210-220	2	-
220-230	2	1
230-240	1	-
240-250	1	4
250-260	2	1
260-270	1	-
270-280	1	-
290-300	1	-
320-330	-	1
330-340	1	-
470-480	-	1
480-490	1	-
Grand Total	159	146

SUBSIDIARIES

The Company has five subsidiary companies:

- IsoScan Limited
- Geological Surveys (New Zealand) Limited
- IsoScan Food Limited
- Geological Risk Limited
- GNS Science International Limited

Dr Nicola Crauford and Ian Simpson were Directors of each of the subsidiary companies at 30 June 2019.

DIVIDENDS

No dividend was declared during the year to 30 June 2019 (2018: \$nil).

DIRECTORS' INDEMNITY AND INTERESTS

The Company has insurance cover for Directors in respect of any act or omission in their capacity as a Director of the Company and its subsidiaries. Directors are indemnified by a Deed of Indemnity, renewed annually, whereby the Company indemnifies Directors against any liability for any act or omissions incurred in their capacity as a Director. The indemnity for liabilities incurred does not extend to criminal liability or liability for breach of a fiduciary duty owed to the Company.

Directors' interests disclosed during the year to 30 June 2019 are set out in the table below. Interests are directorships unless otherwise stated and do not include trusteeships, directorships or shareholdings in private trusts and small companies with whom no transactions have occurred during the year. These interests have been appropriately recorded in the Director interest register, which is updated monthly.

Director	Position	Organisation
Nicola Crauford	Director	Wellington Water Ltd (until 31 December 2018)
	Director	Environmental Protection Authority
	Director	Watercare Services Ltd
	Director	Orion New Zealand Ltd
	Specialist Advisor	WorleyParsons New Zealand Ltd
	Director and Shareholder	Riposte Consulting Ltd
	Deputy Chair	Fire and Emergency New Zealand (until 7 June 2019)
	Member	Electoral Authority, The Co-operative Bank Ltd
	Member	EPA Decision-making Committee for OMV GSB Ltd's marine discharge consent application
	Independent Chair	Chorus Visionstream UFB Connect Joint Governance Group
Sarah Haydon	Director	Cavalier Corporation Ltd (until 29 October 2018)
	Chair	New Zealand Riding for the Disabled Association Inc
	Associate	The Boardroom Practice Ltd
	Trustee	R&E Seelye Trust
	Director	The Co-operative Bank Ltd
	Director	Ports of Auckland Ltd
Steve Weaver	Fellow	Royal Society of New Zealand
	Director, Chair HR Committee Governance Group	Research and Education Advanced Network NZ (REANNZ)
	Advisor	Resilience National Science Challenge
	Member	GAMA Foundation
Chris Bush	Director and Shareholder	Rose Centre for Stroke Research and Rehabilitation
	Shareholder	SRM Solutions Ltd
John Sharpe	Shareholder	QSP Ltd
	Director and Shareholder	Photara Technologies Ltd
	Director	Accelerenz Ltd
	Director	Sexing Technologies New Zealand Ltd
	Director and Shareholder	Weka Labs Ltd
Paul White	Director	Chronoptics Ltd
	Member	Plant and Food Research, Science Review Panel (July 2018)
	Member	Te Rarawa Iwi
	Chair	Te Rarawa Farming Ltd
	Director	Te Rarawa To Tātou Kainga Ltd
	Chair	Te Waka Pūpuri Pūtea Ltd and Trust and subsidiaries (Te Rarawa Iwi asset holding group)
	Director	Top Energy Ltd and subsidiaries
	Director	Ngawha Geothermal Ltd
	Council Member	Kaunihera Māori, Heritage NZ Pouhere Taonga
	Member	Māori Health Committee, HRC
Director and Shareholder	Torea Tai Consultants Ltd	
Executive Member	Matapihi (Māori housing body)	
Felicity Evans	Executive	ANZ Bank Ltd
	Director	NZ Global Women
	Director	ANZ National Staff Superannuation Ltd
	Director	Arawata Assets Ltd
	Member	State Services Commission ARC

EVENTS SUBSEQUENT TO BALANCE DATE

The Directors are not aware of any matter or circumstance since the end of the financial year not otherwise dealt with in this report that has, or may have, a significant effect on the operation of the Company.

CERTIFICATIONS

The Directors confirm that the Company has operated in accordance with the Crown Research Institutes Act 1992, Crown Entities Act 2004 and the Companies Act 1993 during the year.

The activities undertaken by the Company in the year are in accordance with GNS Science's Statement of Core Purpose.

No written direction was received from either shareholding Minister in the year.

For and on behalf of the Board



Dr Nicola Crauford
Chairman

21 August 2019

FINANCIAL STATEMENTS

CONSOLIDATED STATEMENT OF COMPREHENSIVE INCOME

For the year ended 30 June 2019

<i>in thousands of New Zealand dollars</i>	Note	Actual 2019	Budget 2019	Actual 2018
Revenue				
Research contracts		64,519	64,904	60,429
Commercial		18,213	16,789	16,128
GeoNet services		12,523	12,721	11,978
Other income		59	-	9
Total revenue	2	95,314	94,414	88,544
Operating expenses				
Employee benefit expenses	3	45,730	45,532	41,302
Other operating expenses	3	39,484	36,828	38,183
GeoNet direct expenses		4,203	3,893	3,764
Total operating expenses		89,417	86,253	83,249
Profit before interest, tax, depreciation and amortisation		5,897	8,161	5,295
Depreciation	6	4,852	5,500	4,647
Amortisation and impairment	7	657	500	2,319
Profit/(loss) before interest and tax		388	2,161	(1,671)
Interest income		642	540	672
Interest expense		(4)	-	(33)
Profit/(loss) before tax		1,026	2,701	(1,032)
Income tax	4	(571)	(756)	259
Profit/(loss) after tax		455	1,945	(773)
Other comprehensive income		-	-	(29)
Total comprehensive income attributable to owners		455	1,945	(802)

The accompanying notes form part of these financial statements.

CONSOLIDATED STATEMENT OF CHANGES IN EQUITY

For the year ended 30 June 2019

<i>in thousands of New Zealand dollars</i>	Share capital	Equity reserves		Total equity
		Retained earnings	Cash flow hedge reserve	
Balance at 1 July 2017	6,167	28,715	29	34,911
Loss after tax	-	(773)	-	(773)
Other comprehensive income	-	-	(29)	(29)
Balance at 30 June 2018	6,167	27,942	-	34,109
Profit after tax	-	455	-	455
Balance at 30 June 2019	6,167	28,397	-	34,564

The accompanying notes form part of these financial statements.

CONSOLIDATED BALANCE SHEET

As at 30 June 2019

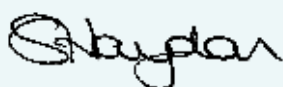
<i>in thousands of New Zealand dollars</i>	Note	Actual 2019	Budget 2019	Actual 2018
Equity				
Share capital	5	6,167	6,167	6,167
Equity reserves		28,397	29,539	27,942
Total equity		34,564	35,706	34,109
<i>Represented by:</i>				
Non-current assets				
Property, plant and equipment	6	27,211	29,642	27,505
Intangible assets	7	846	900	1,195
Investments		30	30	30
Total non-current assets		28,087	30,572	28,730
Current assets				
Cash and cash equivalents		10,132	18,504	2,292
Short term investments		7,500	-	19,000
Trade receivables	8	7,131	7,500	6,872
Prepayments		2,122	1,900	1,838
Current tax		-	-	292
Deferred tax	9	815	(500)	239
Work in progress	2	3,439	2,000	2,009
Total current assets		31,139	29,404	32,542
Total assets		59,226	59,976	61,272
Non-current liabilities				
Non-current provisions	10	1,640	1,838	1,708
Total non-current liabilities		1,640	1,838	1,708
Current liabilities				
Trade and other payables	11	8,178	8,160	10,571
Current provisions	10	3,145	3,045	3,200
Revenue in advance	2	11,412	11,000	11,684
Provision for income tax		287	227	-
Provision for dividend	5	-	-	-
Total current liabilities		23,022	22,432	25,455
Total liabilities		24,662	24,270	27,163
Net assets		34,564	35,706	34,109

The accompanying notes form part of these financial statements.

For and on behalf of the Board



Dr Nicola Crauford
Chairman
21 August 2019



Sarah Haydon
Deputy Chairman
21 August 2019

CONSOLIDATED STATEMENT OF CASH FLOWS

For the year ended 30 June 2019

<i>in thousands of New Zealand dollars</i>	Note	Actual 2019	Budget 2019	Actual 2018
Cash flows from operating activities				
<i>Cash was provided from:</i>				
Receipts from customers		93,064	92,664	85,540
Interest received		567	540	597
		93,631	93,204	86,137
<i>Cash was applied to:</i>				
Payments to suppliers and employees		(92,531)	(85,976)	(79,874)
Interest paid		(4)	-	(33)
Income tax paid		(568)	615	(1,484)
		(93,103)	(85,361)	(81,391)
Net cash flows from operating activities	12	528	7,843	4,746
Cash flows from investing activities				
<i>Cash was provided from:</i>				
Sale of property, plant and equipment		3	-	-
Maturity of short term investments		26,500	-	33,000
		26,503	-	33,000
<i>Cash was applied to:</i>				
Purchase of property, plant, equipment and intangible assets		(4,192)	(7,350)	(4,009)
Placement of short term investments		(15,000)	-	(34,000)
		(19,192)	(7,350)	(38,009)
Net cash flows from investing activities		7,311	(7,350)	(5,009)
Cash flows from financing activities				
<i>Cash was applied to:</i>				
Dividends paid	5	-	(250)	-
		-	(250)	-
Net cash flows from financing activities		-	(250)	-
Net increase/(decrease) in cash and cash equivalents		7,839	243	(263)
Effects of exchange rate changes on the balance of cash held in foreign currencies		1	-	-
Opening cash and cash equivalents		2,292	18,261	2,555
Closing cash and cash equivalents		10,132	18,504	2,292

The accompanying notes form part of these financial statements.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

For the year ended 30 June 2019

1. REPORTING ENTITY AND ACTIVITIES

The Institute of Geological and Nuclear Sciences Limited (trading as GNS Science) is established under the Crown Research Institutes Act 1992 and the Companies Act 1993. Its subsidiary companies are established under the Companies Act 1993. These financial statements have been prepared in accordance with the Crown Research Institutes Act 1992, the Public Finance Act 1989, the Companies Act 1993, the Crown Entities Act 2004 and the Financial Reporting Act 2013.

Consolidated financial statements for the Group comprising the Institute of Geological and Nuclear Sciences Limited (the Parent) and its subsidiaries are presented and the effects of intra-group transactions are eliminated in the consolidated financial statements. Subsidiaries are those entities controlled by the Parent. Control is achieved where the Parent has the power to govern the financial and operating policies of an entity to obtain benefits from its activities.

The wholly owned subsidiaries of the Parent are:

- IsoScan Limited
- IsoScan Food Limited
- Geological Surveys (New Zealand) Limited
- Geological Risk Limited
- GNS Science International Limited.

The principal activities of the Group are to undertake geoscience and isotope science research, development and commercial projects, predominantly in New Zealand. GNS Science International Limited holds a 50% interest in EDDI Project, an unincorporated joint operation formed to undertake a contract for dam hazard management in Vietnam.

Revenue for the year was derived as follows:

in thousands of New Zealand dollars

	2019	2018
Strategic Science Investment Fund contracts	34,502	32,007
Contestable funding contracts	23,693	24,432
Marsden funding contracts	813	1,155
Research subcontracts	5,511	2,835
Research contracts	64,519	60,429
Commercial — New Zealand	11,579	11,632
Commercial — overseas	6,634	4,496
Commercial revenue	18,213	16,128
GeoNet services	12,523	11,978
Other income	59	9
Total revenue	95,314	88,544

A total of \$10.3m (2018: \$13.9m) of revenue recognised in 2019 relates to funds that were included in contract liabilities (revenue in advance) at 30 June 2018.

2. REVENUE

Strategic Science Investment Fund

The Parent is party to a Strategic Science Investment Fund agreement with the Crown to perform research activities that support the Parent's Statement of Core Purpose. Revenue under this contract is treated as a Government Grant under NZ IAS 20 *Accounting for Government Grants and Disclosure of Government Assistance*. All core funded contracts were completed in accordance with the agreement during the year.

Revenue from other research contracts

The Group recognises revenue based on the consideration to which the Group expects to be entitled in a contract with a customer. The Group recognises revenue when it transfers control of a product or service to a customer.

Revenue relating to these contracts is measured based on the stage of completion of the contract. Where any entitlement condition is not yet met, amounts already received are recorded as a contract liability (revenue in advance). Contract assets (work in progress) are recorded for work performed, where funding is expected but has not yet been received.

Commercial revenue and GeoNet services

Contract assets (work in progress) are recorded for any work performed. Any amounts previously recognised as a contract asset are transferred to trade receivables at the point the customer is invoiced for the product or service delivered.

There is not considered to be a significant finance component to the valuation of revenue, due to revenue generally being recognised during the period of related service/product delivery, or within one year.

Movement in contract assets and liabilities

The movement in contract assets and liabilities relating to all sources of revenue is as follows:

<i>in thousands of New Zealand dollars</i>	2019	2018
Contract assets		
Work in progress at 1 July	2,009	3,052
Increase/(decrease) during the year	1,430	(1,043)
Work in progress at 30 June	3,439	2,009
Contract liabilities		
Revenue in advance at 1 July	11,684	15,050
Increase/(decrease) during the year	(272)	(3,366)
Revenue in advance at 30 June	11,412	11,684

Contract assets and liabilities vary from year to year, dependent on the delivery terms of contracted work, and the timing of agreed invoicing or funding received between the Group and contracted parties.

3. EMPLOYEE BENEFIT EXPENSES AND OTHER OPERATING EXPENSES

Employee benefit expenses includes an amount of \$528,000 (2018: \$648,000) relating to termination benefits payable at 30 June 2019, as the Parent can no longer withdraw the offer of those benefits.

Other operating expenses are made up as follows:

<i>in thousands of New Zealand dollars</i>	2019	2018
Services and contracts	15,909	12,660
Research contracts	14,044	15,668
Travel and vehicle	2,749	3,000
Site and communication	2,434	2,216
Materials and supplies	2,432	2,361
Conferences and training	923	812
Rent	178	247
Directors' fees	195	169
Auditor's remuneration – audit services	107	78
Bad debts and credit losses on doubtful debts	(40)	84
Foreign exchange loss/(gain)	15	(34)
Loss/(gain) on disposal of property plant and equipment	(3)	506
Other operating expenses	541	416
Total other operating expenses	39,484	38,183

4. INCOME TAX

The income tax expense is determined as follows:

<i>in thousands of New Zealand dollars</i>	2019	2018
Reconciliation of income tax expense		
Profit/(loss) before income tax	1,026	(1,032)
Tax at rate of 28%	287	(289)
Non deductible items in determining assessable income	21	30
Prior period adjustment	263	-
Total tax expense/(credit)	571	(259)
The taxation charge is represented by		
Current tax	1,147	437
Deferred tax	(576)	(696)
Total tax expense/(credit)	571	(259)

Under section OB1(2)(d) of the Income Tax Act (2007), the Parent is not required to maintain an imputation credit account.

5. SHARE CAPITAL

<i>in thousands of New Zealand dollars</i>	2019	2018
Authorised and issued capital: 6,167,000 ordinary shares	6,167	6,167

All ordinary shares rank equally with respect to dividends and repayment of capital and each carry the right to one vote at any annual meeting.

No dividend has been declared for the year ended 30 June 2019 (2018: \$nil).

6. PROPERTY, PLANT AND EQUIPMENT

Property, plant and equipment are stated at cost less accumulated depreciation and impairment. Cost includes expenditure that is directly attributable to the acquisition of the item. Assets have been depreciated on a straight-line basis at rates calculated to allocate the assets' cost over their estimated remaining useful lives. Freehold land is not depreciated.

The estimated useful lives, residual values and depreciation methods are reviewed annually, with the effect of any changes in estimate accounted for on a prospective basis.

The gain or loss arising on the disposal or retirement of an item of property, plant and equipment is recognised in the Statement of Comprehensive Income.

The following useful lives are used in the calculation of depreciation:

Buildings and improvements	
• wooden construction	40 years
• concrete construction	50 years
• improvements	10 – 20 years
Plant, machinery and laboratory equipment	3 – 15 years
Furniture, fittings and office equipment	3 – 15 years
IT equipment	4 – 8 years
Vehicles	5 years

Heritage assets – collections, library and databases

The Parent owns various collections, library resources and databases that are an integral part of the research work undertaken by the Parent. These collections are highly specialised and there is no reliable basis for establishing a valuation.

The two major collections are:

- The National Paleontological Collection
- The National Petrological Reference Collection

<i>in thousands of New Zealand dollars</i>	Land	Buildings and improvements	Plant and machinery	Laboratory equipment	IT equipment	Furniture, fittings and office equipment	Vehicles	Total
Cost								
Balance at 1 July 2017	2,527	19,987	4,512	29,085	7,217	3,515	1,205	68,048
Additions	-	1,033	99	1,514	632	174	-	3,452
Disposals	-	(3)	(3)	(766)	(304)	(39)	(6)	(1,121)
Balance at 30 June 2018	2,527	21,017	4,608	29,833	7,545	3,650	1,199	70,379
Additions	-	1,065	485	1,738	1,015	239	16	4,558
Disposals	-	-	-	-	-	-	-	-
Balance at 30 June 2019	2,527	22,082	5,093	31,571	8,560	3,889	1,215	74,937
Accumulated depreciation								
Balance at 1 July 2017	-	8,997	2,276	19,600	5,296	2,292	775	39,236
Disposals	-	-	(2)	(656)	(303)	(41)	(7)	(1,009)
Depreciation	-	1,201	327	1,717	979	272	151	4,647
Balance at 30 June 2018	-	10,198	2,601	20,661	5,972	2,523	919	42,874
Disposals	-	-	-	-	-	-	-	-
Depreciation	-	1,275	327	1,808	1,063	250	129	4,852
Balance at 30 June 2019	-	11,473	2,928	22,469	7,035	2,773	1,048	47,726
Net book value at 30 June 2018	2,527	10,819	2,007	9,172	1,573	1,127	280	27,505
Net book value at 30 June 2019	2,527	10,609	2,165	9,102	1,525	1,116	167	27,211

7. INTANGIBLE ASSETS

Software, patents and capitalised development costs have a finite life and are included at cost less accumulated amortisation and impairment. Amortisation is charged on a straight-line basis at rates calculated to allocate the assets' cost over their estimated remaining useful lives.

The estimated useful life and amortisation methods are reviewed annually, with the effect of any changes in estimate being accounted for on a prospective basis.

The following useful lives are used in the calculation of amortisation:

Software	4 – 8 years
Capitalised development costs	4 – 8 years
Patents	4 – 20 years

<i>in thousands of New Zealand dollars</i>	Software	Patents	Capitalised development costs	Total
Cost				
Balance at 1 July 2017	11,309	1,167	650	13,126
Additions	455	55	–	510
Disposals	(183)	(634)	(136)	(953)
Balance at 30 June 2018	11,581	588	514	12,683
Additions	292	16	–	308
Disposals	–	–	–	–
Balance at 30 June 2019	11,873	604	514	12,991
Accumulated amortisation				
Balance at 1 July 2017	8,536	540	650	9,726
Amortisation	821	77	–	898
Disposals	(82)	(339)	(136)	(557)
Impairment	1,421	–	–	1,421
Balance at 30 June 2018	10,696	278	514	11,488
Amortisation	476	38	–	514
Disposals	–	–	–	–
Impairment	–	143	–	143
Balance at 30 June 2019	11,172	459	514	12,145
Net book value at 30 June 2018	885	310	–	1,195
Net book value at 30 June 2019	701	145	–	846

In June 2019, the value of previously capitalised patents was reviewed. A number of patents were determined to have no future benefit. A full impairment of \$143,000 of the carrying amount was made.

In May 2018, a sector downturn, increasing competition and reduced sales of a software offering led management to undertake an impairment review of certain capitalised software development costs.

An independent third party was engaged to undertake a Discounted Cash Flow (DCF) value in use assessment of the intangible asset. The DCF model included analysis of historical (seven years) and projected (eight years) cash flows using a discount rate of 15.5%. Revenue projections were based on a seven year normalised historical average and costs were modelled based on likely expenditure and resourcing levels required to generate the projected revenue streams. The estimated recoverable amount for the capitalised software development costs supported a full impairment of the carrying amount of \$1,421,000.

8. TRADE RECEIVABLES

<i>in thousands of New Zealand dollars</i>	2019	2018
Trade receivables	7,158	6,986
Allowance for credit losses from doubtful debts	(27)	(114)
Total trade receivables	7,131	6,872

Ageing profile of past due trade receivables at balance date

<i>in thousands of New Zealand dollars</i>	2019	2018
Past due 1 – 30 days	410	675
Past due 31 – 60 days	217	187
Past due over 60 days	193	785
Total past due trade receivables	820	1,647

The Group recognises a loss allowance for expected credit losses on trade receivables. The amount of expected credit losses is updated at each reporting date to reflect changes in the assessed credit risk since initial recognition of the respective receivable. At 30 June 2019 all overdue receivables have been assessed for impairment and appropriate provisions for estimated credit losses applied.

The credit quality of trade receivables that are past due but not impaired is otherwise considered sound.

The carrying value of receivables is considered to approximate their fair value.

Movement in the allowance for credit losses

<i>in thousands of New Zealand dollars</i>	2019	2018
Balance at 1 July	114	30
Accounts written off during the year	(47)	-
Increase in credit loss allowance recognised in profit/loss before tax	27	110
Reversal of credit loss allowance on receivables subsequently received	(67)	(26)
Total allowance for credit losses at 30 June	27	114

9. DEFERRED TAX

Deferred tax is accounted for using the comprehensive Balance Sheet liability method in respect of temporary differences arising from differences between the carrying amount of assets and liabilities in the financial statements and the corresponding tax base of those items. In principle, deferred tax assets or liabilities are recognised for taxable temporary differences.

Deferred tax assets are recognised to the extent that it is probable that sufficient taxable amounts will be available against which deductible temporary differences or unused tax losses and tax offsets can be utilised.

The carrying amount of deferred tax assets is reviewed and reduced to the extent that it is no longer probable that sufficient assessable income will be available to allow all or part of the assets to be recovered.

Deferred tax assets and liabilities are measured at the tax rates that are expected to apply in the period in which the liability is settled or the asset realised.

Analysis of temporary differences

<i>in thousands of New Zealand dollars</i>	2019	2018
<i>Deferred tax assets/(liabilities) arise from the following:</i>		
Property, plant and equipment	(741)	(1,059)
Intangible assets	19	(28)
Provisions	1,527	1,292
Allowance for credit losses from doubtful debts	8	32
Capitalised relocation expenses	2	2
Deferred tax asset recognised at 30 June	815	239

Movements in deferred tax

<i>in thousands of New Zealand dollars</i>	2019	2018
Balance at 1 July	239	(457)
Charged to income	605	679
Adjustments — prior year	(29)	17
	576	696
Total deferred tax asset at 30 June	815	239

10. EMPLOYEE ENTITLEMENTS

Liabilities for wages and salaries, annual leave, long service leave and retirement leave are recognised when it is probable that settlement will be required and they are capable of being reliably measured.

Employee benefits to be settled within twelve months are reported at the amount expected to be paid and are classified as current liabilities. Employee benefits not expected to be settled within twelve months are reported at the present value of the estimated future cash outflows.

Provisions for long service leave and retirement leave depend on a number of assumptions such as the expected employment period of employees and salary levels.

<i>in thousands of New Zealand dollars</i>	Current		Non-current	
	2019	2018	2019	2018
Annual leave	2,620	2,566	710	786
Long service leave	432	508	815	781
Retirement leave	93	126	115	141
Total provision for employee entitlements	3,145	3,200	1,640	1,708

11. TRADE AND OTHER PAYABLES

<i>in thousands of New Zealand dollars</i>	2019	2018
Trade payables	4,066	6,804
Accrued expenses	4,112	3,767
Total trade and other payables	8,178	10,571

Trade and other payables are non-interest bearing and are normally settled on the 20th of the month following receipt of invoice. The carrying value of creditors and other payables approximates their fair value.

12. CASH AND CASH FLOWS

Cash and cash equivalents and short term investments

Cash and cash equivalents consist of deposits at call and short term deposits with original maturities of less than three months. Short term deposits consist of investments with original maturity periods of between three and twelve months and are presented as a separate line item in the financial statements.

Reconciliation of profit after tax to net cash flows from operating activities

<i>in thousands of New Zealand dollars</i>	2019	2018
Profit/(loss) after tax	455	(773)
Add/(less) items classified as investing activities:		
Net loss/(gain) on disposal of property, plant and equipment	(3)	506
Adjust non-cash items:		
Depreciation	4,852	4,647
Amortisation and impairment	657	2,319
(Decrease)/increase in credit allowance for doubtful debts	(40)	84
Net unrealised exchange gain	(1)	(113)
Increase/(decrease) in provision for income tax	579	(1,047)
Increase in deferred tax asset	(576)	(696)
Decrease in non-current provisions	(68)	(149)
	5,403	5,045
Add/(less) movements in working capital items:		
Increase in accounts receivable and prepayments	(504)	(761)
Decrease in payables, current provisions and revenue in advance	(2,720)	(363)
Change in receivables and payables relating to investing activities	(673)	49
(Increase)/decrease in work in progress	(1,430)	1,043
	(5,327)	(32)
Net cash flows from operating activities	528	4,746

13. RELATED PARTY TRANSACTIONS

The Crown is the ultimate shareholder of the Parent. No other transactions with New Zealand Government owned entities are considered as related party transactions in terms of NZ IAS 24 *Related Party Disclosures*.

The total remuneration paid to Directors and key management personnel during the year was as follows:

<i>in thousands of New Zealand dollars</i>	2019	2018
Short term benefits	2,134	2,212

Balances and transactions between the Parent and its subsidiaries, which are related parties, have been eliminated on consolidation and are not disclosed in this note.

Transactions between entities in the Group and Damwatch Projects Limited are disclosed below. Damwatch Projects Limited is a related party because it is a 50% partner with GNS Science International Limited, of the EDDI Project, an unincorporated joint operation.

<i>in thousands of New Zealand dollars</i>		Revenue/Purchases			Amounts payable/receivable at 30 June	
		2019	2018		2019	2018
GNS Science International Limited	<i>Revenue</i>	122	213	<i>Payable</i>	-	163
Damwatch Projects Limited	<i>Purchases</i>	122	213	<i>Receivable</i>	-	163

The amounts owed between the parties are unsecured and have been settled in cash. No guarantees have been given or received. No provisions have been made for doubtful debts in respect of any amounts owed between related parties. Distributions owing to GNS Science International Limited at 30 June 2019 total \$8,620 (2018: \$5,780).

14. FINANCIAL INSTRUMENTS

Capital management

The Group manages its capital to ensure that entities in the Group will operate in a financially responsible manner, be financially viable and continue as going concerns.

The Group is not subject to any externally imposed capital requirements.

Currency risk

The Group undertakes certain transactions denominated in foreign currencies. Exchange rate exposures are managed within approved policy limits using forward foreign exchange contracts.

These derivative financial instruments are initially recognised at fair value on the date the derivative contract is entered into and are subsequently remeasured to their fair value at the end of each reporting period. Derivatives are carried as assets when the fair value is positive and as liabilities when the fair value is negative. The resulting gain or loss is recognised in the Statement of Comprehensive Income immediately, unless the derivative is designated effective as a hedging instrument, in which event the timing of the recognition in the Statement of Comprehensive Income depends on the nature of the hedging relationship.

The effective portion of changes in the fair value of cash flow hedges is recognised in other comprehensive income and accumulated in a cash flow hedge reserve. The gain or loss relating to any ineffective portion is recognised immediately in the Statement of Comprehensive Income.

At balance date the Group had no forward foreign exchange contracts in place (2018: \$nil).

At 30 June the carrying amounts of the Group's foreign currency denominated assets and liabilities were:

<i>in thousands of New Zealand dollars</i>	Liabilities		Assets	
	2019	2018	2019	2018
Australian Dollar	(57)	(43)	215	110
Canadian Dollar	-	(2)	1	-
Euro	(70)	(122)	122	41
Pound Sterling	-	(64)	1	50
Hong Kong Dollar	-	-	6	-
Indonesian Rupiah	(3)	-	-	-
Japanese Yen*	-	-	-	-
Norwegian Krone	(84)	(114)	-	-
Omani Rial	-	-	-	435
US Dollar	(128)	(181)	572	405
	(342)	(526)	917	1,041

*At 30 June 2019 the Parent carried Japanese Yen in cash, but its value was less than \$1,000 NZD

Interest rate risk

The Group has deposits on call as well as short term deposits on which interest is earned. Where possible, the Group manages exposures to interest rate fluctuations through prudent management of its treasury operations. Interest rates for short term deposits held at 30 June 2019 ranged between of 3.25% and 3.45% (2018: 2.20% and 3.51%).

In managing interest rate risks the Group aims to reduce the impact of short term fluctuations on earnings. Over the longer term permanent changes in interest rates will have an impact on profit.

Market risk and sensitivity analysis

As at 30 June 2019, if the New Zealand dollar had strengthened by 5% against foreign currencies, with all other variables held constant, the profit before tax for the year would have decreased by \$27,000 (2018: \$17,000). A 5% weakening of the New Zealand Dollar would have increased reported profit before tax by \$30,000 (2018: \$18,000).

If interest rates had been 50 basis points higher/lower and all other variables were held constant, reported profit before tax for the year would increase/decrease by \$18,000 (2018: \$110,000).

Credit risk management

The financial instruments which expose the Group to credit risk are principally bank balances, short term investments and accounts receivable. The Group monitors credit risk on an ongoing basis.

Bank balances and short term investments are held with New Zealand registered banks in accordance with the Group's treasury policy.

No collateral is held by the Group in respect of bank balances, short term investments or accounts receivable. The maximum exposure to credit risk is represented by the carrying value of each financial asset in the Balance Sheet.

Liquidity risk

The Group manages liquidity risk by maintaining adequate reserves, cash deposits and short term investments, by monitoring forecast and actual cash flows and by matching the maturity profiles of financial assets and liabilities, all of which are of a short term nature. The Group continues to generate sufficient cash flows from operations to meet financial liabilities.

15. COMMITMENTS

Non-cancellable operating lease commitments

Operating lease payments are recognised on a systematic basis representing the pattern in which economic benefits from the leased asset are consumed over the lease term.

Leases are classified as finance leases whenever the terms of the lease transfer a significant portion of all of the risks and rewards of ownership to the lessee. All other leases are classified as operating leases.

The Group has no leases which would be classified as finance leases.

<i>in thousands of New Zealand dollars</i>	2019	2018
Within one year	163	32
Between one and five years	92	18
Over five years	-	-
Total non-cancellable operating lease commitments	255	50

Capital commitments

<i>in thousands of New Zealand dollars</i>	2019	2018
Contracted and on order	907	582
Authorised but not yet contracted	2,115	1,528
Total capital commitments	3,022	2,110

16. CONTINGENT LIABILITIES

The Group has no contingent liabilities (2018: \$nil).

17. EVENTS AFTER THE BALANCE DATE

There were no significant events after the balance date (2018: none).

18. PREPARATION DISCLOSURES

Statement of compliance

The financial statements have been prepared in accordance with New Zealand generally accepted accounting practice. They comply with New Zealand equivalents to International Financial Reporting Standards and other applicable Financial Reporting Standards, as appropriate for profit-oriented entities. The financial statements also comply with International Financial Reporting Standards.

Accounting policies have been applied consistently to all periods presented in the financial statements except for minor changes relating to the adoption of NZ IFRS 15 *Revenue from Contracts with Customers*, and NZ IFRS 9 *Financial Instruments*.

NZ IFRS 15, which was adopted for the first time on 1 July 2018, has had no impact on the Group's revenue recognition. The standard has been applied retrospectively with the effects at initial application being recognised at adoption date.

There has been no change to revenue recognition in the financial statements as a result of the transitional provision.

There have been no changes to the measurement and classification of financial instruments following the adoption of NZ IFRS 9.

Measurement basis

The financial statements of the Group have been prepared on a historical cost basis, except that derivative financial instruments are measured at their fair value.

Transactions in foreign currencies are converted at the New Zealand rate of exchange ruling on the date of the transaction. Monetary assets and liabilities at year end are converted to New Zealand dollars at the exchange rate ruling at balance date.

The financial statements are presented in New Zealand dollars which is the Group's functional currency. All values are rounded to the nearest thousand dollars.

Interest in joint arrangements

A joint arrangement is an arrangement whereby the Parent or its subsidiaries have joint control over an entity. Joint control is the contractually agreed sharing of control of an arrangement, which exists only when decisions about the relevant activities of that entity require the unanimous consent of the parties sharing control. A joint arrangement is either a joint operation or a joint venture. For a joint operation the Group recognises its share of assets, liabilities, revenues and expenses on a line-by-line basis using the proportionate method. For a joint venture the Group recognises its interest in a joint venture as an investment and accounts for that investment using the equity method.

Classification of financial assets and liabilities

The Group's financial assets consist of cash and cash equivalents, short term investments and trade receivables. These are measured at amortised cost. In the case of trade receivables, cost is reduced by an allowance for credit losses for doubtful debts.

The expected credit losses on trade receivables are analysed based on the Group's historical credit loss experience, adjusted for factors that are specific to the debtors, general economic conditions and an assessment of both the current and forecast direction of conditions at the reporting date.

Changes in the assessed value of doubtful debts are provided for as a credit risk allowance. New allowances are recognised in the Statement of Comprehensive Income. When a trade receivable is considered uncollectible, it is written off against the allowance. Subsequent recoveries of amounts previously written off are credited against the allowance.

Financial liabilities, excluding derivative financial instruments, consist of trade and other payables and are initially measured at fair value, net of transaction costs. They are subsequently measured at amortised cost. Derivative financial instruments are measured at fair value.

Critical accounting estimates and judgements

In applying the accounting policies, there is the requirement for judgements, estimates and assumptions to be made about the carrying amounts of some assets and liabilities. The estimates and assumptions are based on historical experience and other relevant factors. Actual results may differ from these estimates.

Accounting policies where critical estimates have been made include property, plant and equipment, intangible assets, impairment of assets, liabilities and employee benefits. Judgement has been applied in determining not to value heritage assets for financial reporting purposes.

New standards and interpretations not yet adopted

Standards and interpretations effective in the current period — there are no new standards and interpretations effective in the current period with a material impact.

Standards and interpretations approved but not yet in effect — new or revised standards and interpretations that have been approved but are not yet in effect have not been adopted for the year ended 30 June 2019.

The key items applicable to the Group are:

NZ IFRS 16 Leases

(effective for periods beginning on or after 1 January 2019)

NZ IFRS 16 requires a lessee to recognise a lease liability reflecting future lease payments and a "right-of-use asset" for virtually all lease contracts. The Group intends to adopt NZ IFRS 16 on 1 July 2019. The Group is assessing the full impact of this standard and anticipates that for leases that are on medium term to long term arrangements, liabilities and assets with a value of up to \$250,000 may need to be recorded for leases with existing contracted arrangements as at 1 July 2019.

The adoption of other standards and interpretations is not expected to have a material recognition or measurement impact on the financial statements. These will be applied when they become mandatory.

STATEMENT OF RESPONSIBILITY

The Board is responsible for the preparation of the Group's annual financial statements and statement of performance and for the judgements made in them.

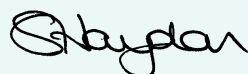
The Board through management is responsible for establishing and maintaining a system of internal control designed to provide reasonable assurances as to the integrity and reliability of the financial reporting.

In the opinion of the Board, the annual financial statements and statement of performance for the financial year fairly reflect the financial position and operations of GNS Science.

For and on behalf of the Board



Dr Nicola Crauford
Chairman
21 August 2019



Sarah Haydon
Deputy Chairman
21 August 2019

INDEPENDENT AUDITOR'S REPORT

To the readers of Institute of Geological and Nuclear Sciences Limited Group's financial statements for the year ended 30 June 2019

The Auditor-General is the auditor of Institute of Geological and Nuclear Sciences Limited Group (the Group). The Auditor-General has appointed me, Trevor Deed, using the staff and resources of Deloitte Limited, to carry out the audit of the financial statements of the Group on his behalf.

Opinion

We have audited the financial statements of the Group on pages 70 to 85, that comprise the consolidated balance sheet as at 30 June 2019, the consolidated statement of comprehensive income, consolidated statement of changes in equity and consolidated statement of cash flows for the year ended on that date and the notes to the financial statements that include accounting policies and other explanatory information.

In our opinion, the financial statements of the Group:

- present fairly, in all material respects:
 - its financial position as at 30 June 2019; and
 - its financial performance and cash flows for the year then ended; and
- comply with generally accepted accounting practice in New Zealand in accordance with New Zealand Equivalents to International Financial Reporting Standards and International Financial Reporting Standards.

Our audit was completed on 21 August 2019. This is the date at which our opinion is expressed.

The basis for our opinion is explained below. In addition, we outline the responsibilities of the Board of Directors and our responsibilities relating to the financial statements, we comment on other information, and we explain our independence.

Basis for our opinion

We carried out our audit in accordance with the Auditor-General's Auditing Standards, which incorporate the Professional and Ethical Standards and the International Standards on Auditing (New Zealand) issued by the New Zealand Auditing and Assurance Standards Board. Our responsibilities under those standards are further described in the Responsibilities of the auditor section of our report.

We have fulfilled our responsibilities in accordance with the Auditor-General's Auditing Standards.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Responsibilities of the Board of Directors for the financial statements

The Board of Directors is responsible on behalf of the Group for preparing financial statements that are fairly presented and that comply with generally accepted accounting practice in New Zealand.

The Board of Directors is responsible for such internal control as it determines is necessary to enable it to prepare financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, the Board of Directors is responsible on behalf of the Group for assessing the Group's ability to continue as a going concern. The Board of Directors is also responsible for disclosing, as applicable, matters related to going concern and using the going concern basis of accounting, unless the Board of Directors has to cease operations, or has no realistic alternative but to do so.

The Board of Directors' responsibilities arise from the Crown Research Institutes Act 1992.

Responsibilities of the auditor for the audit of the financial statements

Our objectives are to obtain reasonable assurance about whether the financial statements, as a whole, are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion.

Reasonable assurance is a high level of assurance, but it is not a guarantee that an audit carried out in accordance with the Auditor-General's Auditing Standards will always detect a material misstatement when it exists. Misstatements are differences or omissions of amounts or disclosures and can arise from fraud or error. Misstatements are considered material if, individually or in the aggregate, they could reasonably be expected to influence the decisions of readers taken on the basis of these financial statements.

For the budget information reported in the financial statements, our procedures were limited to checking that the information agreed to the Group's statement of corporate intent and the budget approved by the Board.

We did not evaluate the security and controls over the electronic publication of the financial statements.

As part of an audit in accordance with the Auditor-General's Auditing Standards, we exercise professional judgement and maintain professional scepticism throughout the audit. Also:

- We identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.
- We obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances but not for the purpose of expressing an opinion on the effectiveness of the Group's internal control.
- We evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by the Board of Directors.
- We conclude on the appropriateness of the use of the going concern basis of accounting by the Board of Directors and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the Group's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However, future events or conditions may cause the Group to cease to continue as a going concern.
- We evaluate the overall presentation, structure and content of the financial statements, including the disclosures and whether the financial statements represent the underlying transactions and events in a manner that achieves fair presentation.
- We obtain sufficient appropriate audit evidence regarding the financial statements of the entities or business activities within the Group to express an opinion on the consolidated financial statements. We are responsible for the direction, supervision and performance of the Group audit. We remain solely responsible for our audit opinion.

We communicate with the Board of Directors regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

Our responsibilities arise from the Public Audit Act 2001.

Other Information

The Board of Directors is responsible for the other information. The other information comprises the information included on pages 4 to 69 and 89 to 90, but does not include the financial statements, and our auditor's report thereon.

Our opinion on the financial statements does not cover the other information and we do not express any form of audit opinion or assurance conclusion thereon.

In connection with our audit of the financial statements, our responsibility is to read the other information. In doing so, we consider whether the other information is materially inconsistent with the financial statements or our knowledge obtained in the audit, or otherwise appears to be materially misstated. If, based on our work, we conclude that there is a material misstatement of this other information, we are required to report that fact. We have nothing to report in this regard.

Independence

We are independent of the Group in accordance with the independence requirements of the Auditor-General's Auditing Standards, which incorporate the independence requirements of Professional and Ethical Standard 1 (Revised): *Code of Ethics for Assurance Practitioners* issued by the New Zealand Auditing and Assurance Standards Board.

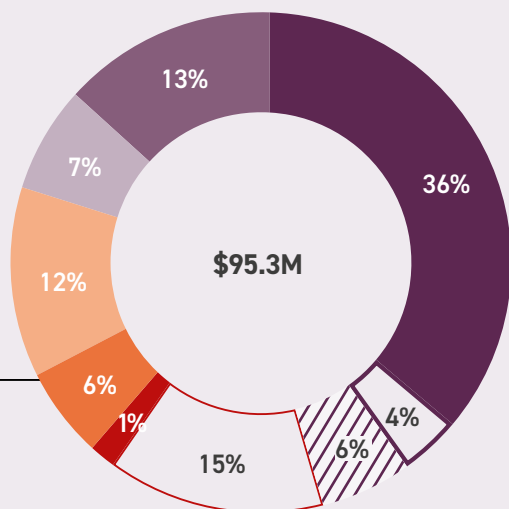
Other than the audit, we have no relationship with, or interests in, the Group.



Trevor Deed, Partner
for Deloitte Limited
On behalf of the Auditor-General
Wellington, New Zealand

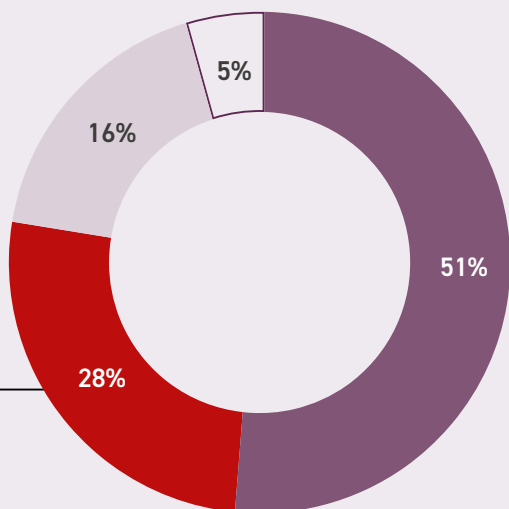
OUR YEAR IN NUMBERS

REVENUE BY SECTOR OUTCOME AREAS



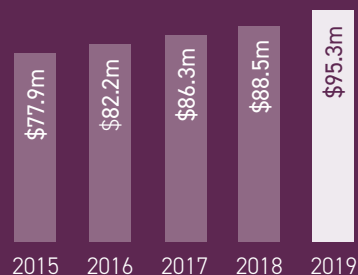
- Strategic Science Investment Fund
- Natural Hazards Research Platform
- Resilience to Nature's Challenges
- Contestable funding contracts
- Marsden funding contracts
- Research subcontracts
- Commercial - New Zealand
- Commercial - overseas
- GeoNet

HOW WE SPENT OUR MONEY

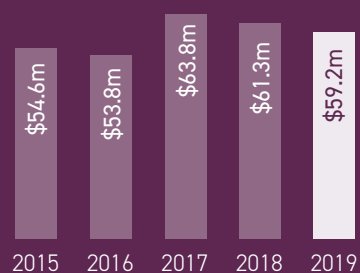


- Employee related costs
- GeoNet direct costs
- Research contracts
- Other operating costs

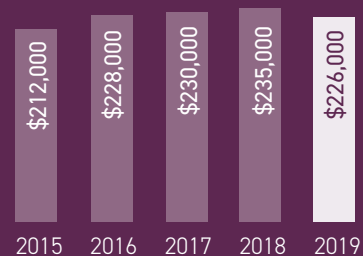
REVENUE (\$M)



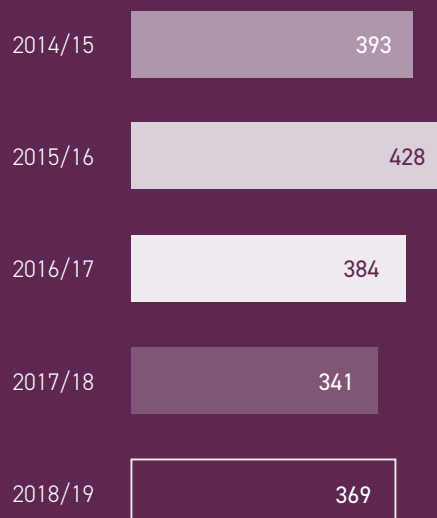
TOTAL ASSETS (\$M)



REVENUE PER FTE (\$)



PEER-REVIEWED PUBLICATION FIGURES



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Email: gracefield@gns.cri.nz

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Private Bag 2000
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Tel: +64 7 374 8211
Email: wairakei@gns.cri.nz

Dunedin Research Centre

764 Cumberland Street
Private Bag 1930
Dunedin 9054
New Zealand

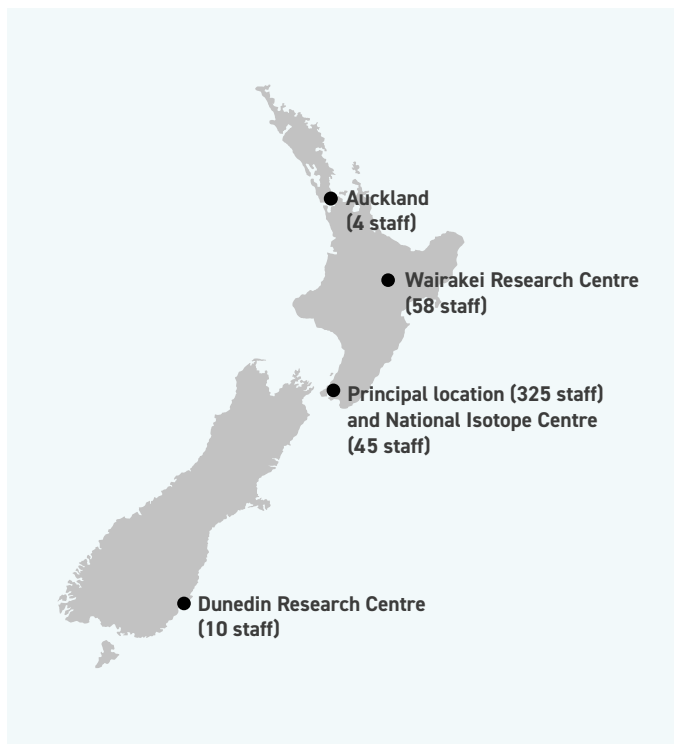
Tel: +64 3 477 4050
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New Zealand

Tel: +64 4 570 1444
Email: auckland@gns.cri.nz

OUR OFFICE LOCATIONS AND STAFFING



DIRECTORS

Dr Nicola Crauford
(Chairman)

Sarah Haydon
(Deputy Chairman)

Chris Bush

Felicity Evans

Dr John Sharpe

Paul White

COMMUNICATIONS MANAGER

Simone Keough
Email: s.keough@gns.cri.nz

BANKERS

ANZ

AUDITOR

Trevor Deed
Deloitte Limited
On behalf of the
Auditor-General

SOLICITORS

Chapman Tripp

WEBSITES

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

EXECUTIVE LEADERSHIP TEAM

Chief Executive
Ian Simpson

General Manager, Strategy & Chief Scientist
Dr Gary Wilson

General Manager, Stakeholder Relations
Justine Daw

General Manager, Science
Peter Benfell

Interim General Manager, Business Services
Andrew Simpson

General Manager, People and Culture
Rose Macfarlane

Principal Māori Relations Advisor
Tania Gerrard

PHOTOGRAPH ACKNOWLEDGEMENTS

Agnes Mazot, GNS Science	P52	Lance Lawson	P47
Alan Blacklock, NIWA	P23, 27	Lloyd Homer, GNS Science	P40
Bernard Spragg	P40	Manoj Kalathara, GNS Science	P32
Brad Scott, GNS Science	Cover image and P35	Margaret Low, GNS Science	P2, 7, 8, 9, 16, 18, 20, 24, 26, 31, 35, 36, 41, 42, 43, 48, 49
Carol Stewart, Massey University	P17	Marie Helliwell, GNS Science	P14
Cawthron Institute	P25	Martin Crundwell, GNS Science	P39
Chris Sisarich, NZ Story	P30	Michael O'Neill, Museum of NZ Te Papa	P17
Colin McDiarmid	P5, 56, 59	Nancy Bertler, GNS Science	P22, 28, 29
Craig Stevens, NIWA	P28	Regine Morgenstern, GNS Science	P19
Dougal Townsend, GNS Science	P34	Resilient Organisations	P21
Graham Hancox, GNS Science	P19	Richard Johnson, GNS Science/EQC	P53
Hocken Collections, University of Otago	P38	Sigrun Hreinsdottir, GNS Science	P6
Jocelyn Turnbull, GNS Science	P51	Simon Woolf Photography	P8
John Callan, GNS Science	P15, 43, 48, 49	Tobias Keller	P62
Julian Thomson, GNS Science	P20, 51	Top Energy Ltd	P33
Karen Britten, GNS Science	P50	Vera Christmann, GNS Science	P9
Kate Clark, GNS Science	P19	Victoria University of Wellington	P52
Kyle Bland, GNS Science	P18, 37, 39		

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



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

