GNS SCIENCE **2018** ANNUAL REPORT


WE MOVE
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FORWARD
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LAND AND
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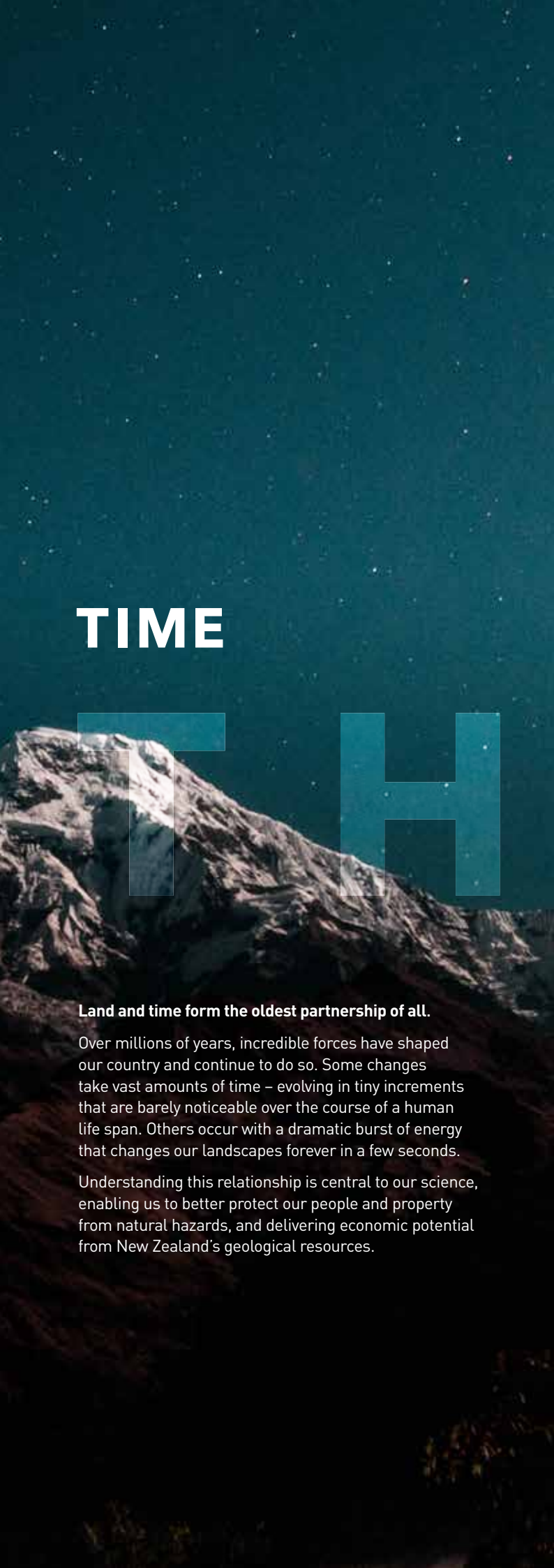
TIME



Land and time form the oldest partnership of all.

Over millions of years, incredible forces have shaped our country and continue to do so. Some changes take vast amounts of time – evolving in tiny increments that are barely noticeable over the course of a human life span. Others occur with a dramatic burst of energy that changes our landscapes forever in a few seconds.

Understanding this relationship is central to our science, enabling us to better protect our people and property from natural hazards, and delivering economic potential from New Zealand's geological resources.

PEOPLE IN PARTNERSHIP

Our internal and external partnerships enable our success.

Our people are our greatest asset – it is the work we do using our collective skills and experience that drives our success. We are sharply focused on working as a team to meet our strategic goals and deliver value to New Zealand and New Zealanders.

Our relationships with other Crown Research Institutes, universities, local and central government, iwi, and international science organisations all enable us to share knowledge and resources, gain new perspectives, and work together to enhance the many and varied ways we contribute to making our country a cleaner, safer and more prosperous place to live.

HE WAKA

A CANOE WHICH WE ARE

Our partnership with Māori is very important to us.

It reflects a mutual interest in and commitment to understanding the whenua and a shared commitment to a vision of a cleaner, safer and more prosperous nation for the benefit of Māori and all New Zealanders.

Te Rautaki Umanga Māori, our Māori business strategy, helps define our relationships with Māori, and underpins the work we do to help Māori protect their precious resources and harness economic value from them.

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GNS SCIENCE

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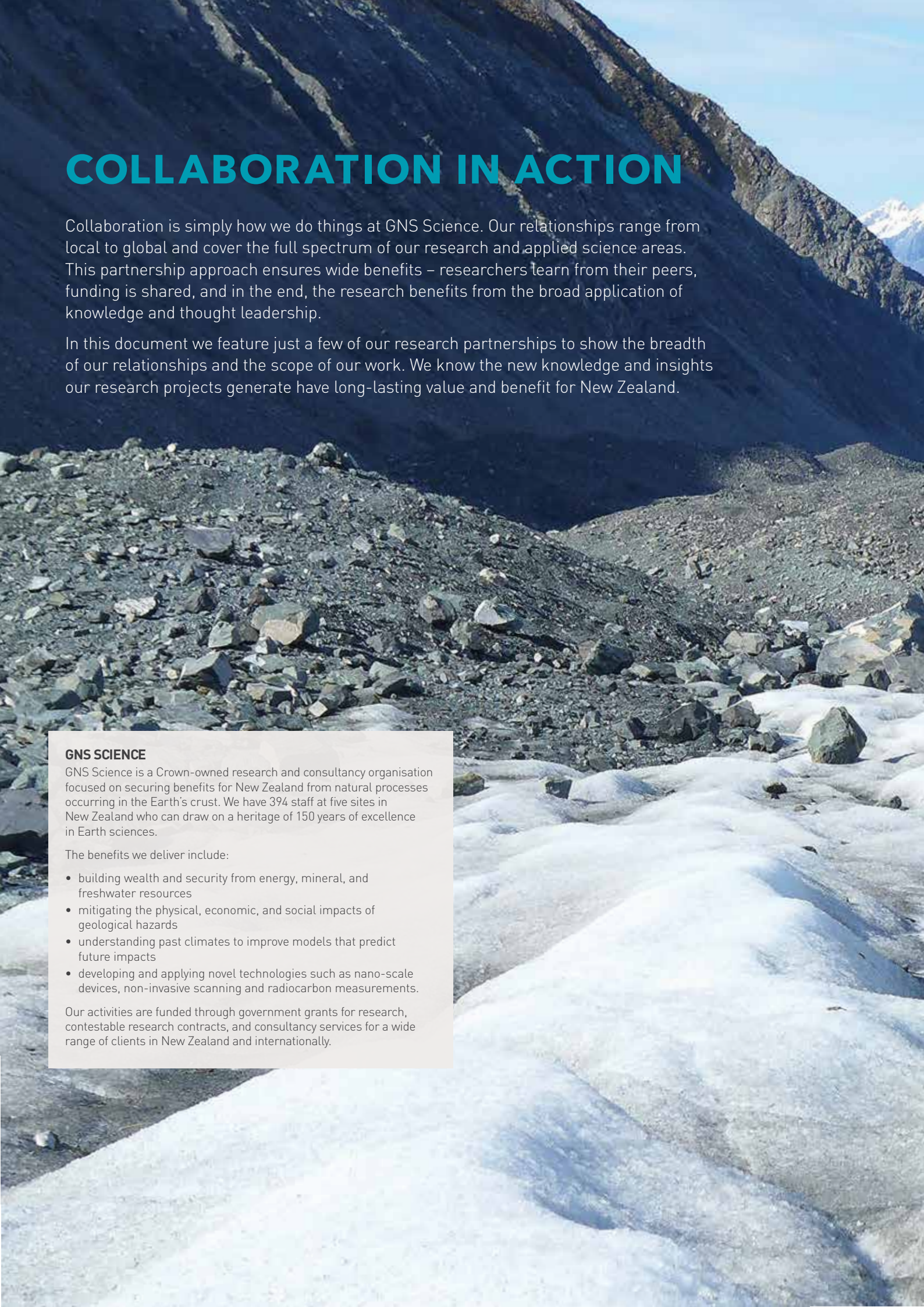
COLLABORATION IN ACTION

Collaboration is simply how we do things at GNS Science. Our relationships range from local to global and cover the full spectrum of our research and applied science areas. This partnership approach ensures wide benefits – researchers learn from their peers, funding is shared, and in the end, the research benefits from the broad application of knowledge and thought leadership.

In this document we feature just a few of our research partnerships to show the breadth of our relationships and the scope of our work. We know the new knowledge and insights our research projects generate have long-lasting value and benefit for New Zealand.



GNS SCIENCE

GNS Science is a Crown-owned research and consultancy organisation focused on securing benefits for New Zealand from natural processes occurring in the Earth's crust. We have 394 staff at five sites in New Zealand who can draw on a heritage of 150 years of excellence in Earth sciences.

The benefits we deliver include:

- building wealth and security from energy, mineral, and freshwater resources
- mitigating the physical, economic, and social impacts of geological hazards
- understanding past climates to improve models that predict future impacts
- developing and applying novel technologies such as nano-scale devices, non-invasive scanning and radiocarbon measurements.

Our activities are funded through government grants for research, contestable research contracts, and consultancy services for a wide range of clients in New Zealand and internationally.

ACHIEVEMENTS / TOGETHER

SCIENCE / TOGETHER

PEOPLE / TOGETHER

NUMBERS / TOGETHER

OUR YEAR IN NUMBERS

HIGHLIGHTS

$88.2M

Total revenue

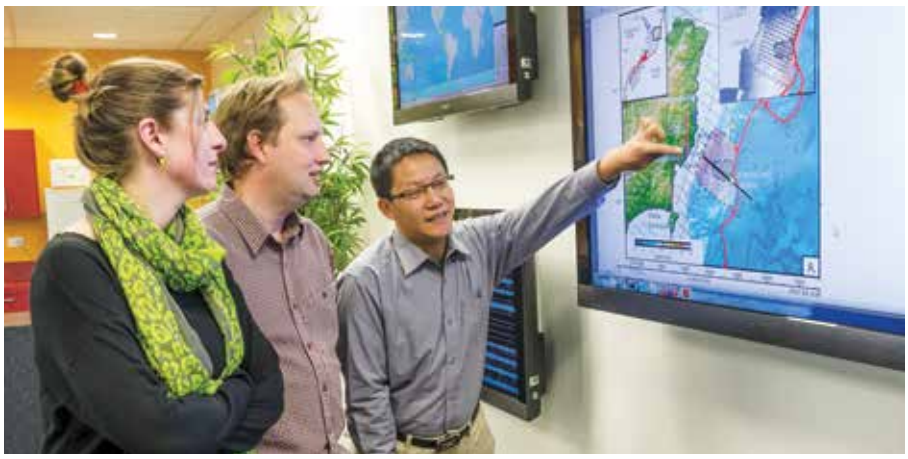
AWARDS

The 2018 *Nature Index* rated GNS Science as the top-ranked corporate institution in the world for the output of our publications in earth and environmental sciences.

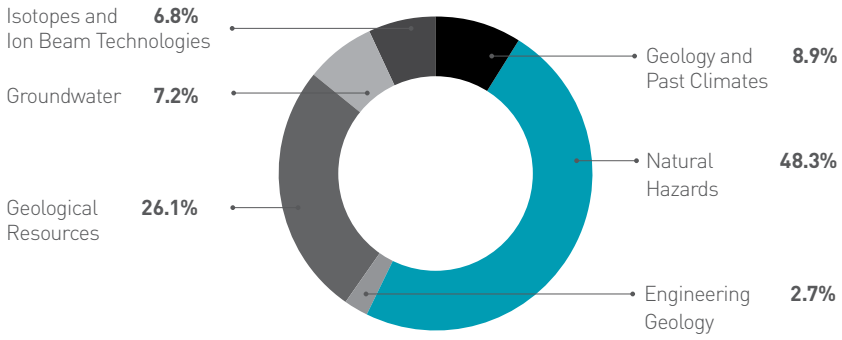
OUR PEOPLE

376.3

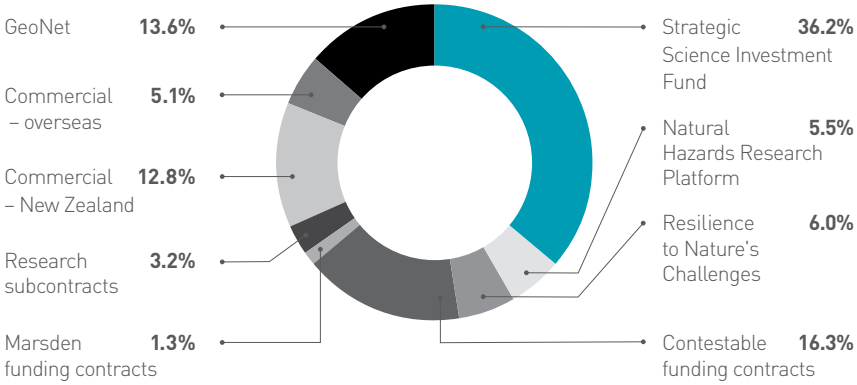
Full-time equivalent staff



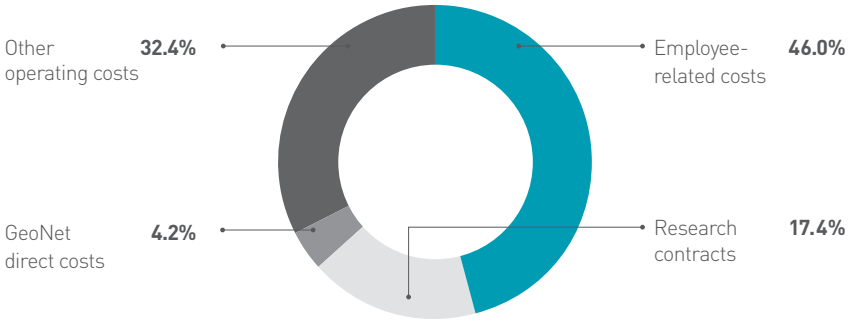
REVENUE BY SECTOR OUTCOME AREAS



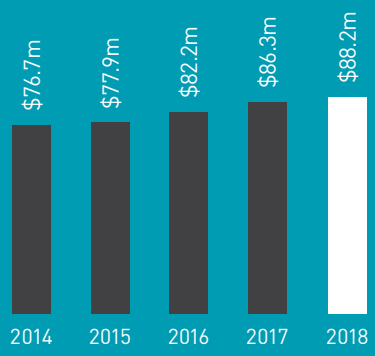
REVENUE SOURCES



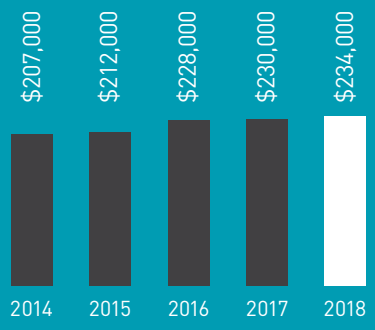
HOW WE SPENT OUR MONEY



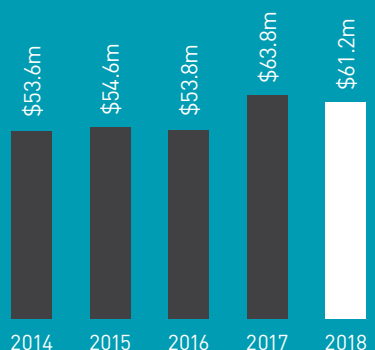
REVENUE



REVENUE PER FTE



TOTAL ASSETS



FROM THE CHAIRMAN AND CHIEF EXECUTIVE

WORKING TOGETHER TO DELIVER OUR VISION

GNS Science occupies a unique place in New Zealand's science landscape. With our strong foundation of world-leading Earth science research, coupled with people at GNS Science who are passionate and committed, we are well positioned to bring our vision of a cleaner, safer, more prosperous nation to life.

This Annual Report reflects the organisational transition we are going through. While our core purpose stands firm, we've had a period of reflection to develop a strategy that builds on our excellent science so that we continue to be relevant and have impact where it matters most.

Over the past year we've been gearing up to be more deliberate about how we address the changing needs of New Zealanders: a heightened awareness of groundwater as a vital resource, understanding and increasing resilience to the natural hazards we face, the significance of the continent of Zealandia to the country's future, and the need to transition to a low carbon economy. This strong focus on end-user impact and outcomes is apparent in our priorities for the diverse range of our activities.

Underpinning these activities is the vast amount of geoscience information that we've produced and collated over more than 150 years. These rich datasets are available to others to inform their decision-making, for example in land-use planning or hazards mitigation.

We continue to look for opportunities to share our knowledge. We know we're not on this road alone. And we know our most effective work comes out of collaborations we've forged with science partners, local government, iwi, industry and others. This Annual Report offers snapshots of the way we work – together – to achieve better results for New Zealanders.

FINANCIAL RESULT

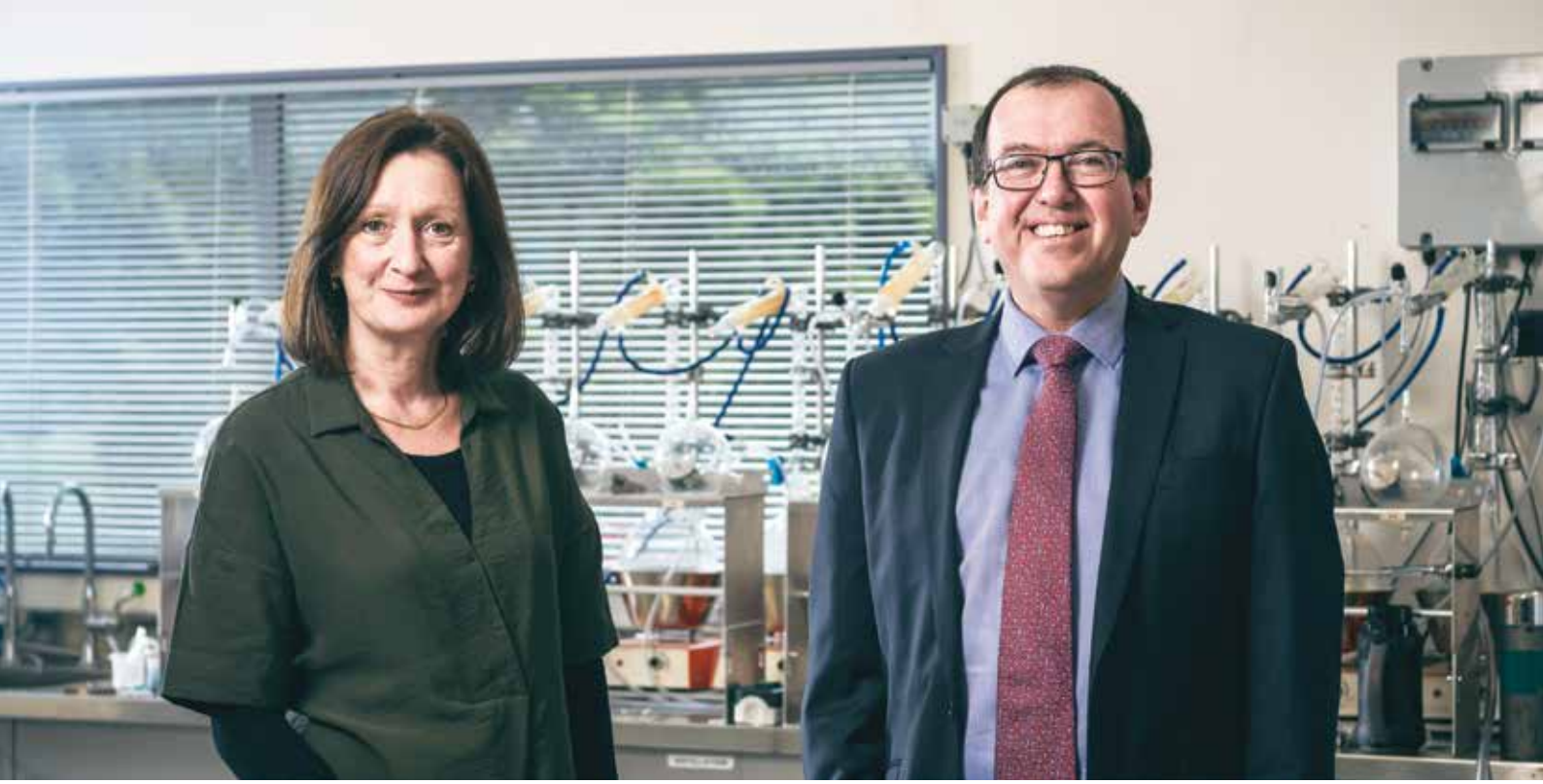
For the year to 30 June 2018, we posted an after-tax loss of $773,000 against a budgeted profit of $3.1m. This has been a year of change and aligning investment with strategy. Our commercial revenue (including the petroleum sector) declined by $4.5m but this was partly offset by an increase in research contracts of $3.1m. We have also incurred a range of costs this year to set us up on a growth path going forward. This included asset write-offs of $1.76m and restructuring costs of $0.9m, of which $650,000 are termination payments. By dealing with these issues now, we are set up on a strong financial footing for next year and beyond.

STRATEGIC REVIEW

The focus of our strategy is growth and development. Building on the expertise, innovation and talent of our people, we are positioning our organisation for the future.

The strategic review, started in March 2017 with input from external stakeholders, developed five foundation pillars which will enable this transition and support its success. These pillars are the focus areas for the reviews and initiatives that have begun in the last year and will continue over the next few years. They are:

- Investing for and with purpose – linking our role, purpose and activities with New Zealand's strategic needs
- From 'decision-taker' to 'decision-maker' – improving our connections with a wide range of stakeholders including officials and government so we can contribute meaningfully to making New Zealand cleaner, safer and more prosperous
- Culture change – collaborative behaviour and activities where our strategic direction drives our funding
- Deep partnering – building strong relationships that are mutually beneficial and long term
- Awareness – together raising our profile to enhance engagement, trust, and ultimately advocacy from our stakeholders and New Zealanders.



The first stage of the review, a restructure of the executive and corporate areas, was implemented on 1 August 2018 after consultation, then recruitment. Five General Manager positions (Strategy, Science, Stakeholder Relations, Business Services, and People and Culture), and a Principal Māori Relationships Advisor position were established to report directly to the Chief Executive. Several new corporate positions were also scoped and filled.

We reviewed the science programmes funded through the Strategic Science Investment Fund (SSIF) to identify our areas of strength and where we have the greatest impact. As a result, we are putting more emphasis on exploring Zealandia, understanding our groundwater resources, enhancing our hazards research, broadening our support for Vision Mātauranga, and developing a strategy for managing 'big data'.

Our globally influential research on climate change will remain a key focus area for SSIF funding. Through our ongoing work on CO_2 emissions and mitigations, and air quality; rising sea level projections; and climate change impacts on marine and terrestrial ecosystems, we are well placed to significantly contribute to national climate change science and policy. This work in understanding the drivers of climate change informs action and policy development to mitigate its effects, helping New Zealand transition to a low carbon economy.

A broader review of the science structure and programmes is underway. This is due to be completed in December 2018 with implementation the following year. All this work is putting us in a solid position to focus our energy, leverage our knowledge and achievements, and build our connections.

We already produce excellent, internationally-recognised science and the changes we are making will enable us to more accurately meet the current and future needs of New Zealand. That means ensuring we are investing in areas where we have strength along the science value chain, and the culture, structures, capability and capacity in place to deliver on our goals.

ENDORSEMENT FOR THE QUALITY OF OUR WORK

Our research won international recognition this year in the annual *Nature Index* tables which placed us as the top ranked corporate institution in the world for the number and quality of our publications in earth and environmental sciences. We also came eighth in the 'all science disciplines' category in the world *Index*.

COMMUNICATING OUR SCIENCE

Peer-reviewed articles in high impact science journals

255

Commissioned reports accepted by users

222

Within New Zealand, GNS Science ranked first for earth and environmental sciences and fourth across all science disciplines. The *Index* is a measure of publication productivity at the institutional and national level and, as such, is one indicator of global high-quality research output and is also an international endorsement for our staff and their outstanding work.

RESILIENCE TO NATURE'S CHALLENGES

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

Collaboration is the cornerstone of the approach: so far, the Challenge has brought together more than 100 researchers seeking new scientific solutions as we plan for, respond to and recover from natural hazards.

Since 2015, the Challenge Governance Group and the Challenge Parties have helped communities, planners and industry to understand and compare multiple hazards, and build effective new practices that are fit for purpose and meet community needs.

THE ADVENT OF 24/7 GEONET

From late 2018 GeoNet will move to operating 24 hours-a-day and seven days-a-week and have a hi-tech dedicated monitoring centre at our Lower Hutt headquarters. It will be the most significant upgrade since GeoNet came into being in 2001.

Staff in the 24/7 centre will have access to multiple data-streams from GeoNet's monitoring stations around New Zealand. This will give them high situational awareness and contribute to the Ministry of Civil Defence and Emergency Management's rapid response to hazard events. The development is being funded by a $19.5 million investment made by the Government following the November 2016 Kaikōura earthquake.

Our operation centre will monitor earthquakes, volcanoes, tsunamis, and landslides bringing efficiencies and synergies on many levels. Underpinning these enhancements are the proven capabilities of GeoNet. These have evolved over the past 17 years in response to geohazard events, particularly the series of events since the Canterbury earthquake sequence which started in 2010.

The enhanced operation will provide a high and consistent level of information to all our stakeholders.

At the same time, discussions are underway with our principal GeoNet partner – EQC – to strengthen and streamline our governance arrangements, particularly important given the increasing number of GeoNet customers.

LEADERSHIP IN MARINE GEOSCIENCE

Big science in its most authentic form came to New Zealand in the past year. We are referring to the series of six voyages of the scientific drilling ship *JOIDES Resolution* under the auspices of the 23-nation International Ocean Discovery Program. New Zealand is part of this international effort through its membership of the Australian and New Zealand International Ocean Discovery Program Consortium. A small team at GNS Science coordinates New Zealand participation in IODP, reflecting our ability to form a cohesive unit from numerous research organisations.

The *JOIDES Resolution* is one of the world's top geoscience research ships and it typically visits New Zealand only once or twice a decade for a single mission. To have the vessel for nearly 18 months to undertake six voyages of discovery in New Zealand waters is unprecedented. Researchers from GNS Science either led or participated in all the voyages. (Pages 13 to 15 have more detailed coverage of these voyages.)

As an island nation with one of the largest marine jurisdictions in the world, New Zealand has continental-scale responsibilities and opportunities. This was reflected in the programme's four key science themes – climate and ocean change, sub-seafloor life, deep Earth processes, and geohazards.

As well as the direct scientific benefits, membership of IODP delivers invaluable training opportunities for the next generation of New Zealand scientists and engineers, plus unrivalled opportunities for students, teachers, and the public to engage with marine science. While the *JOIDES Resolution* was in Lyttelton and Auckland between voyages, we hosted guided tours of the ship. Outreach activities also included live ship-to-shore video links to schools, universities, and museums.

CHANGES TO THE GNS SCIENCE BOARD

Felicity Evans joined our Board on 1 July 2018. Felicity has more than 25 years' experience in the banking and finance industries, and brings refreshing new perspectives to our Board.

STAFF CHANGES

Change is always challenging. Developing a new strategy and direction, no matter the opportunities it presents, inevitably brings uncertainty and anxiety for the people involved. We express our thanks to our staff. They've taken every opportunity to be involved, and they've shown resilience and patience.

We have increased the establishment number by 11.2 FTEs in our new executive and corporate structures. The role of the larger corporate teams is to build our capability and capacity to achieve greater visibility, efficiency, influence and application for our science.

Even though our executive team has changed, we are indebted to our former division directors for their leadership and the rich knowledge they contributed, helping us as we transition to a new way of working.

With the structural change to our corporate services division complete and the review of our science divisions underway, we are working to become more agile and adaptable to the changing needs of New Zealand, and the world.

Importantly, during all of this, our people have had another successful year delivering innovative, applied science through research and projects that help protect and enhance New Zealand's wellbeing. The following pages offer a glimpse into the range of our ongoing activities.

LOOKING TO THE FUTURE

Ehara taku toa i te toa takitahi, engari he toa takitini. Success is not in the work of one, but the work of many. We couldn't have reached this point without the outstanding work that's been done this year and the passionate, capable people driving it. We look forward to navigating the next stage of our development together. We welcome the future knowing we bring a long, proud history with us. It is the best of both worlds.

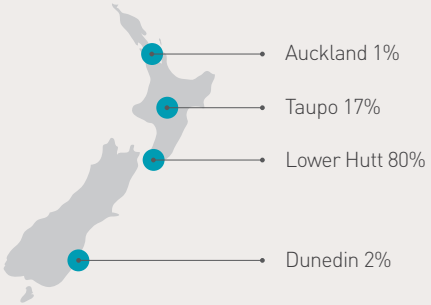
Dr Nicola Crauford
Chairman
September 2018

Ian Simpson
Chief Executive
September 2018

GNS SCIENCE AT A GLANCE

GNS Science, Te Pū Ao, is the Crown-owned science company in New Zealand that focuses on geological resources, environmental and industrial isotopes, and geological hazards. We apply this scientific knowledge to deliver on our vision of a cleaner, safer, more prosperous New Zealand.

STAFF



Our 394 staff are located in Lower Hutt (80%), Taupo (17%), Dunedin (2%) and Auckland (1%).

THE BENEFITS WE DELIVER FOR NEW ZEALAND INCLUDE:

- wealth and security from energy, mineral, and water resources
- mitigation of the economic and social effects of geological hazards
- development of new technologies such as nano-scale devices and non-invasive scanning.

OUR RESEARCH FOCUSES ON PROCESSES AND ENDOWMENTS WITHIN THE EARTH'S CRUST INCLUDING:

- rocks, minerals, and groundwater
- earthquakes, volcanoes, landslides, and tsunamis
- geothermal energy and hydrocarbons
- climate history and geobiology
- gravitational and electromagnetic fields
- natural isotopes and radiation.

SCOPE AND GOVERNANCE

We operate a limited liability company owned by the New Zealand government, and with an independent Board of Directors. We invest most of our tax-paid profit in scientific equipment and infrastructure. This ensures our capabilities keep pace with, or lead, international standards.

Our clients include:

- New Zealand central government agencies
- regional and local government
- overseas government agencies
- geothermal energy exploration and operating companies
- hydroelectricity operating companies
- the onshore and offshore minerals exploration industries
- oil and gas exploration companies
- meat, dairy, wool, timber, and horticulture processing industries
- insurance and reinsurance companies
- engineers, developers, and infrastructure companies
- museums
- research organisations in New Zealand and overseas.

REVENUE

Our revenue ($88 million in 2017-18) is generated from:

- direct government grants for research (approximately 35%)
- contestable public-good research contracts (15-20%)
- consultancy services, product development, and analytical services for the private sector, and for central and local government (30-35%)
- monitoring geological hazards for the Earthquake Commission (10-15%).

Visit our website: www.gns.cri.nz

ACHIEVING TOGETHER

GNS Science is privileged to have exceptional staff who make an extraordinary contribution to New Zealand. During the past year, a number of our staff were recognised for their outstanding contributions to science.

Emeritus scientist **Alan Beu** marked 50 years of employment at GNS Science and its predecessor organisations in 2018.

Marine geoscientist **Jenny Black** was awarded the Geoscience Society of New Zealand's 'Kingma Award' for outstanding Earth science technician of 2017.

Electronic engineer **George Chisholm** was awarded an Emerging Innovator grant from KiwiNet to gain skill and experience around innovation and commercialisation.

Paleontologist **Roger Cooper** won the Hutton Medal for his huge and far-reaching body of work on fossil zooplankton from the early Paleozoic (510-440 million years ago).

Paleontologist **James Crampton** was elected as a Fellow of the Paleontological Society, a US-based international society. The honour is given to members who have made a significant contribution to research, teaching, or service to the profession. James is the first New Zealand-based paleontologist to hold one of these fellowships.

Marine geochemist **Cornel de Ronde** was awarded a Joubin James visiting professorship at the University of Toronto.

Seismologist **Donna Eberhart-Phillips** was awarded an American Geophysical Union Fellowship. This award recognises Donna's outstanding contributions to Earth science over many years. Each year AGU elects new Fellows who have shown visionary leadership and scientific excellence.

Former GeoNet Director **Ken Gledhill** won a Lifetime Achievement award at the inaugural Science New Zealand National Awards in November 2017. Ken was a key player in getting GeoNet started in 2001 and has shown superb leadership as this group has become a household name in recent years.

Climate scientist **Nick Golledge**, who has a joint appointment with GNS Science and Victoria University of Wellington, was awarded the 'McKay Hammer' at the 2017 GeoScience conference.

Remote sensing scientist **Ian Hamling** won the Hamilton Award for Early Career Research Excellence in the Royal Society's 2017 annual awards. The award was for Ian's work in advancing the understanding of New Zealand's tectonic and volcanic processes using satellite-based techniques.

Seismologist **Caroline Holden** was awarded a NZ Society for Earthquake Engineering Fellowship for her services to earthquake research and earthquake engineering in New Zealand. Caroline was also co-awarded the 2018 Otto Glogau Award for best paper in the preceding three years.

Geologist **Nick Mortimer** was elected as a Fellow of the Royal Society of New Zealand Te Apārangi. Nick has played a leading role in exploring, revealing and promoting the continent of Zealandia. He joins more than 400 Fellows who have been recognised for distinction in research or for advancing science, technology and the humanities.

Ion Beam Material Scientist **Jérôme Leveneur** won an Early Career Researcher award at the inaugural Science New Zealand National Awards in November 2017. Jérôme has achieved extraordinary success within the Ion Beam group since being awarded his PhD in 2012.

Groundwater scientists **Cath Moore** and **Johannes Kaiser** won best oral presentation and best poster, respectively, at the 2017 annual conference of the New Zealand Hydrological Society.

Marine geoscientist **Grant O'Brien** and geologist **Simon Cox** and Victoria University seismologist John Townsend were awarded the Geoscience Society of New Zealand's 2017 New Zealand Geophysics prize.

The ***Nature*** science publication annual *Index* tables placed us the top ranked corporate institution in the world for the number and quality of our publications in Earth and environmental sciences. The *Index* is a measure of high-quality research output by corporate, government, and academic organisations throughout the world.

The **Natural Hazards Research Platform**, hosted by GNS Science, was rated gold in 2017 by the Ministry of Business Innovation and Employment for the third year in a row. Every year, MBIE rates a contract's performance as red, amber, green or gold, with gold signifying performance exceeding expectations.

The New Zealand United Nations Convention on the Law of the Sea (UNCLOS) Project Team won a Team Award at the inaugural Science New Zealand National Awards in November 2017. This group successfully added 1.7 million km² of seabed to New Zealand's offshore sovereign territory. This means New Zealand's entire offshore area is equivalent to 14 times the size of California or 1% of the Earth's surface.

Minerals petrologist **Christian Timm** was awarded a 12-month Marie Curie Fellowship from the European Commission to work at GEOMAR in Germany. Christian is leading a team investigating the transport of metals such as gold, silver, and copper beneath the seafloor along the Kermadec Arc.

Groundwater scientist **Paul White** won the Best Poster Award at the 2017 International Society for Ecological Modelling Global Conference 2017. Paul's poster was on *Modelling Evaluation and Future Management Plan of Water Quality for Lake Rerewhakaaitu, Bay of Plenty, New Zealand.*

FULFILLING OUR PURPOSE TOGETHER

Our business is defined by our Statement of Core Purpose and understanding our place in the national innovation system.

PURPOSE

GNS Science's purpose is to undertake research that drives innovation and economic growth in New Zealand's geologically based energy and minerals industries, that develops industrial and environmental applications of nuclear science, that increases New Zealand's resilience to natural hazards, and that enhances understanding of geological and earth-system processes.

GNS Science will fulfil its Purpose through the provision of research and consultancy services and knowledge in partnership with key stakeholders including industry, government and Māori to achieve the following outcomes.

STATEMENT OF CORE PURPOSE OUTCOME STATEMENTS:

OS1	Increase resource security and economic benefit from the development and diversification of New Zealand's oil, gas, geothermal energy and minerals industries
OS2	Increase New Zealand's resilience to natural hazards and reduce risk from earthquakes, volcanoes, landslides and tsunamis
OS3	Improve the sustainable management of and increase economic returns from groundwater resources
OS4	Create value for New Zealand industry through the use of isotope and ion beam technologies
OS5	Increase understanding of the geology and past climates of New Zealand, the Ross Dependency and Antarctica
OS6	Enhance the geotechnical engineering that underpins New Zealand's transport and energy infrastructure

TO ACHIEVE THESE OUTCOMES, GNS SCIENCE IS THE LEAD CROWN RESEARCH INSTITUTE IN:

- geothermal energy, oil, gas and gas hydrates (including carbon sequestration)
- mineral and geobiological resources
- geological hazards, risk mitigation and social impacts of natural hazards
- earth-system processes and landscape evolution
- groundwater processes and quality
- the geological component of global environmental processes and climate change
- application of nuclear technology and isotope science and ion beam technology.

GNS SCIENCE WORKS WITH OTHER RESEARCH PROVIDERS AND END-USERS TO CONTRIBUTE TO THE DEVELOPMENT OF:

- high-value manufacturing
- freshwater management
- hazards management
- ocean floor exploration
- climate change adaptation and mitigation
- Antarctica.

GNS SCIENCE:

- operates in accordance with a Statement of Corporate Intent that describes how we will deliver against this Statement of Core Purpose, and describes what the shareholders will receive for their investment
- meets its obligations as a Crown company and remains financially viable
- develops strong, long-term partnerships with key stakeholders, including industry, government and Māori, and works with them to set research priorities linked to the needs of end-users
- maintains a balance of research that provides for near-term needs of end-users and also demonstrates longer-term vision
- transfers technology and knowledge from domestic and international sources to key New Zealand stakeholders
- develops collaborative relationships with other research institutions to form the best teams
- provides advice on matters of its expertise to the Crown
- represents New Zealand's interests on behalf of the Crown through contribution to science diplomacy
- seeks advice from advisory panels to help ensure the quality and relevance of our research
- has policies, practices and culture that optimise recruitment and retention
- enables the innovation potential of Māori knowledge, resources and people
- maintains databases, collections and infrastructure sustainably and provides appropriate access
- seeks shareholder consent for significant activity beyond our scope of operation.

The information in this Annual Report demonstrates how GNS Science is delivering on its expected outcomes.

Contracted funding from the Government through the Endeavour Fund and the Strategic Science Investment Fund has reporting requirements that are handled separately to this Annual Report.

GOVERNMENT FUNDING

PRIORITISING OUR CORE FUNDING

Strategic Science Investment Fund programmes reflect New Zealand's changing needs.

The Government's Strategic Science Investment Fund supports longer-term programmes of mission-led science and science infrastructure of enduring importance to New Zealand. SSIF funding is typically structured around 'science platforms'. These are a combination of people, facilities, information and knowledge that provide a particular ongoing science and innovation capability for New Zealand. Investments from this Fund form a significant portion of total government investment in science.

GNS Science is looking to ensure that it invests its core Government funding in the areas of its expertise that will provide the most benefit to New Zealand. We have shifted the priorities for our Strategic Science Investment Fund (SSIF) funding to reflect the changing needs of New Zealanders.

SSIF, which is allocated through the Ministry of Business, Innovation and Employment, accounts for 36 percent of our annual operating revenue.

Keeping in tune with changing societal expectations is crucial for us. Drivers for these include a heightened awareness of water as a vital resource, the natural hazard perils facing New Zealand, and the significance of the mostly submerged continent of Zealandia to the country's future. Our SSIF investment is focused on gaining a better understanding of Zealandia, the hazards and risks we face, and our groundwater resource. GNS Science is strongly influential in these three areas, and our science has a significant role in addressing some of the country's, and the planet's, most pressing issues.

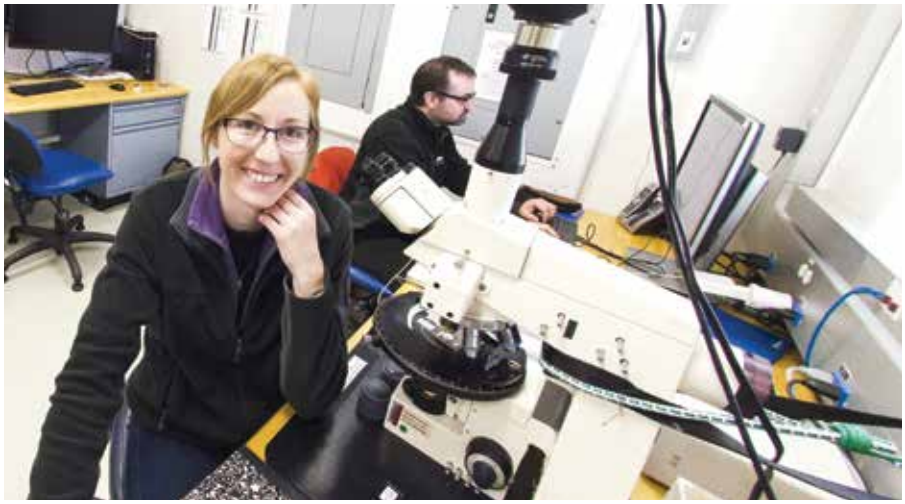
The contribution GNS Science makes to understanding global climate change and sea level rise continues. We are actively seeking commercial opportunities to apply our research in geothermal energy.

There are increases in investment in Vision Mātauranga research, developing a data strategy, and exploring ways to use social science disciplines to increase the influence of our work beyond the current strengths that we have in natural hazards. This shift in priorities, developed and approved by the Board during the year, was implemented on 1 July 2018.

SCIENCE FEATURE

GETTING TO KNOW ZEALANDIA

Understanding the geology, tectonics, climate history, and resources of the mostly submerged continent of Zealandia is an imperative for us. This year we set a high benchmark by being a lead player in six back-to-back voyages on the International Ocean Discovery Program's scientific drill ship *JOIDES Resolution* in New Zealand waters and the Ross Sea.



This flagship mission combines the talents and financial resources of the 23 nations that make up the IODP – the world's largest collaboration in geosciences. The six voyages represent more than $US100 million of investment in New Zealand science – one of the largest ever programme-specific investments in New Zealand science in a single year. The voyages demonstrate the large benefit that accrues from partnership with Australia and collaboration with the international scientific community, and at a small fraction of the actual cost.

Fifty years of scientific ocean drilling within IODP and predecessor programmes has addressed fundamental questions about Earth processes and tackled a wide range of societally relevant research questions, ranging from geological hazards and climate change to the nature of life in extreme environments. The five voyages addressed these questions from a local perspective and as such are closely aligned to GNS Science's strategy and government research priorities.

Securing the 143m-long *JOIDES Resolution* to undertake 18 months of research and discovery in New Zealand waters is unprecedented. It is a working research ship with world-class laboratories and associated facilities for analysing sediment and rock cores from beneath the seafloor.

Staff from GNS Science either led or were participants in all the voyages, which were one to two months long. Each voyage had a crew of about 30 scientists from up to 15 countries. Many more onshore specialists participated in each expedition. This provides invaluable opportunities for New Zealand scientists to collaborate with leading international researchers and use cutting-edge facilities. The voyages and port calls of the *JOIDES Resolution* have also provided unrivalled access for students, teachers, and the public to engage with science through IODP outreach programmes. The outcomes and benefits to New Zealand will continue for many years beyond the life of each expedition.

WHERE WE'RE WORKING

The IODP is the world's largest, longest running, and most successful marine geoscience programme. Its core science themes are climate and ocean change, sub-seafloor life, deep Earth processes, and geohazards.

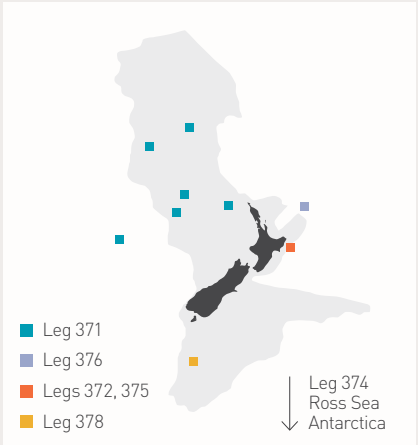
Climate & ocean change

Sub-seafloor life

Deep Earth processes

Geohazards

Zealandia is the 4.9 million square kilometre, mostly submerged, continent on which New Zealand stands. It is roughly the same size as India and half the size of Europe.



The first expedition drilled into the northern Tasman Sea, northwest of the North Island, to investigate how and why tectonic plate subduction began about 50 million years ago, and to determine the influence this has had on regional and global climate.

The second expedition investigated the relationship between gas hydrates and underwater landslides 30km east of Gisborne, and tested their link to glacier-like deformation of parts of the seafloor in this region. It was followed by a voyage to the Ross Sea that recovered sediment cores off the Ross Ice Shelf to gain an improved understanding of the behaviour and stability of the West Antarctic Ice Sheet through multiple cycles of warming and cooling over the past 20 million years.

The fourth voyage installed two sophisticated observatories beneath the seafloor 40km and 90km east of Gisborne respectively to learn more about slow earthquakes that occur on the Hikurangi Subduction zone. The steel-cased observatories will remain under the seafloor for up to 10 years collecting data on how the rocks are strained during slow-slip events. They will also record changes in temperature and the flow of fluids through fault zones.

This information will give scientists important new insights into the behaviour of slow-slip events and their relationship to large, tsunami-generating earthquakes along the subduction plate boundary. It will help to develop capability for giving early warnings of damaging earthquakes and tsunamis off the North Island's east coast, which will help to improve community resilience and reduce losses from future events.

The fifth voyage probed the large and hydrothermally active Brothers Volcano, about 400km northeast of the Bay of Plenty coast, to investigate how metals are transported within submarine volcanoes and brought to the seafloor where they form metallic deposits. Brothers is three times the size of White Island and its summit sits 1200m below sea level. The scientists drilled five boreholes into the heart of Brothers and compiled the most comprehensive information known about a submarine arc volcano.

A sixth voyage, sailing in 2020, will study a very warm climate episode in Earth's history about 50 million years ago. It is anticipated that the seabed cores collected from south and east of New Zealand will improve understanding of Southern Ocean climate dynamics in a greenhouse world. This information will help to improve the understandingof the impacts of global warming.

GNS Science recognises the value of a global coordinated effort to IODP scientific drilling and the significance that the six expeditions will make to new discoveries of Zealandia's past, present and future.

VISION MĀTAURANGA

GNS Science is committed to developing partnerships with Māori to deliver mutual benefit. We collaborate with Māori organisations on a number of projects that contribute to the social, economic, cultural and environmental wellbeing of New Zealand.

RARE TREASURE IN SOUTH WESTLAND OR TE WAHIPOUNAMU

GNS Science is part-way through a three-year project with a South Westland iwi to jointly assess the quantities of a rare blue rock in the Makaawhio River (or Jacobs River) catchment south of Fox Glacier in South Westland. This is the only location in New Zealand where aotea – a semi-precious and distinctive blue or blue-green stone – is found. The rock is revered by Te Rūnanga o Makaawhio as a one of their most special treasures (tino taonga). The iwi has cared for, gathered, traded and gifted it for generations.

As the main source – riverbed stone – is constantly changing due to flooding and landslides, it is a challenge to work out the size of the total resource. As well as working out the size of the resource and the factors affecting the distribution of aotea, the project is building understanding of Earth science as a tool for indigenous development, enterprise, and enhanced environmental management.

Te Rūnanga o Makaawhio, one of 18 hapū within Ngāi Tahu iwi, is interested in commercial development of aotea, but will only do this when they are satisfied the resource can sustain such a use.

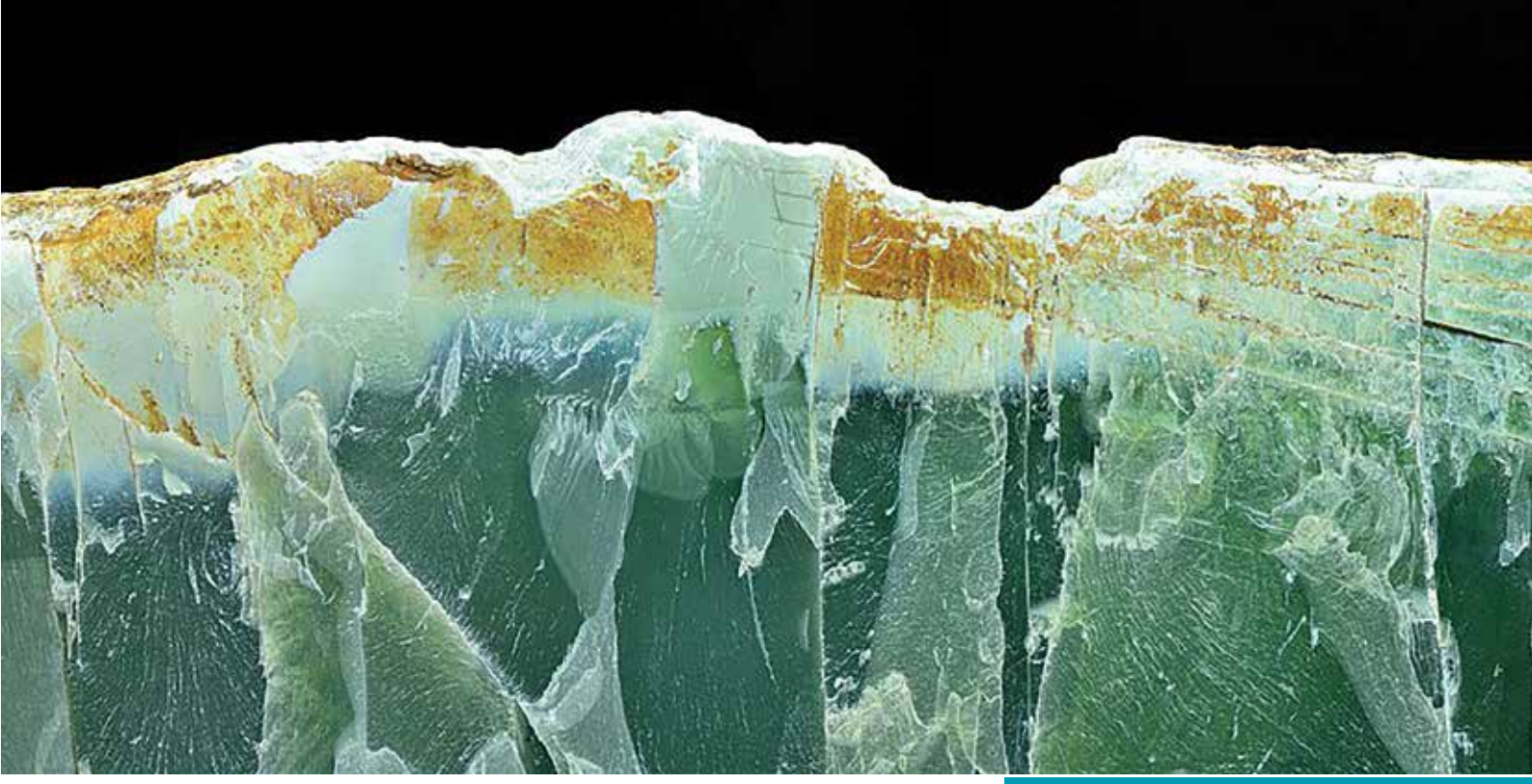
Like pounamu, aotea is amenable to carving and polishing. As it contains the distinctive mineral kyanite, derived from discrete pods beside the Alpine Fault, there is an exciting opportunity to use it as a tracer of sediment movement and river erosion that can lead to locally important and internationally significant science. There may even be potential commercial applications in ceramics and where heat resistance is required, for example in electrical insulators and abrasives.

PRICELESS JADE COLLECTION GIFTED TO GNS SCIENCE

In 2017 GNS Science was gifted a priceless collection of jade specimens by New Zealand jade expert Russell Beck. About half of the 1500 specimens are nephrite jade (pounamu) from New Zealand and the rest are from other countries where jade is found. Known as the 'Beck International Jade Research Collection', it was Russell Beck's personal collection that he had gathered during his lifetime. Beck passed away in early 2018.

The collection consists of 30 large display items, plus many smaller specimens. The gifting occurred at a ceremony at our Lower Hutt office attended by the Beck family and friends, senior Ngāi Tahu and Ngāti Porou officials, representatives from other iwi, government officials, and GNS Science staff. Over the years Beck worked closely with Ngāi Tahu and GNS Science to survey pounamu deposits in the South Island.

The Beck International Jade Research Collection is an internationally unique resource, and one of only a few collections in the world that has specimens from so many countries. It was Beck's wish that the collection remains intact as an active research resource to promote further work on the unique properties and formation of jade. GNS Science is delighted to be looking after this collection on behalf of New Zealand.



EARTH SCIENCE FOR NELSON IWI

We have completed a two-year project building Earth science capacity with Nelson-Marlborough iwi Ngāti Koata, focusing on two minerals in their region – pakohe or argellite and its rare cousin pounamu. Between the 12th and 15th centuries, the mudstone pakohe was the preferred material for stone implements. Known for its hardness and ability to hold a sharp edge, it was used in preparing food, wood carving, flax work, and net making. The source of the pakohe is a belt of rocks geologists refer to as the Dun Mountain Ultramafic Belt, which is about 250-300 million years old.

The MBIE-funded programme consisted of reciprocal visits – iwi representatives visited Wellington for a wānanga to learn about natural landscapes, tectonics, earthquakes, erosion, and the geological history of Nelson. Our geologists also visited the Nelson region for hands-on sessions on geology. This has been backed up with the development of extensive written and digital material as a permanent resource for the iwi. The programme gave Ngāti Koata the ability to use a GIS (Geographic Information System) to record and assess their natural resources. It has also given them the means for more informed management of their resources.

IMPACTS OF HYDROGEN SULPHIDE ON MĀORI WORKFORCE – TE HAUREHU WAIKAWA PUNGATARA E PA ANA TE KAIMAHI MĀORI

GNS Science and Whakarewarewa Village Charitable Trust have been working together to better understand the health effects of hydrogen sulphide and its potential impact on staff at the Village.

The project involves monitoring hydrogen sulphide and carbon dioxide emissions at up to 25 locations at Whakarewarewa Village. We have found that emission rates of both gases differ across the site. We have provided the information to the guides who have included it in their commentaries as they show visitors around the village. An unexpected bonus of the project has been the measurement of high emission values for carbon dioxide in some places. Guides are now using this information to also cover aspects of global warming in their commentaries. The project has improved the understanding of the science of hydrogen sulphide and carbon dioxide and potential health risks at high concentrations.

WORKING IN PARTNERSHIP

The relationship between GNS Science and Te Rūnanga o Ngāi Tahu has been at least a decade in the making, and is based on communication and trust that evolved through research on pounamu, aotea and hot springs in the Southern Alps. Building and protecting sensitive data on these taonga has enabled dialogue on the strategic desires of the rūnanga and how our science can make a difference, and helped inform their kaitiakitanga. Personal friendships have developed over joint fieldwork, cups of tea, and regular phone calls or pop-in visits. This is not something that can be achieved overnight or the week before a proposal is due. Our view is simply and beautifully captured by the old Māori proverb – *What is the most important thing in the world? 'He tangata, he tangata, he tangata' – It is the people, it is the people, it is the people.* Importantly, once meaningful communication is established, it strengthens our collaborations, provides GNS Science with direct links to ask questions about cultural issues, write stronger proposals, and earn a cultural licence to operate.

SCIENCE / TOGETHER

CORE SCIENCE AREA 1:

SCIENCE FOR A CLEANER NEW ZEALAND

CORE SCIENCE AREA 2:

SCIENCE FOR A SAFER NEW ZEALAND

CORE SCIENCE AREA 3:

SCIENCE FOR A MORE PROSPEROUS NEW ZEALAND

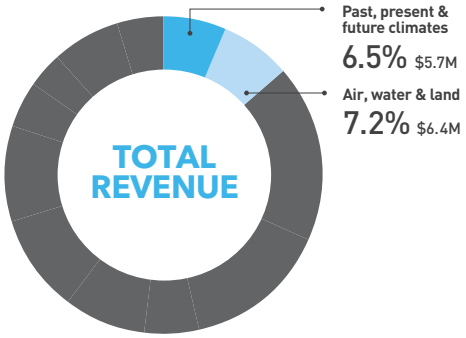
CORE SCIENCE AREA 4:

UNDERPINNING GEOSCIENCE KNOWLEDGE

WHERE OUR RESEARCH FUNDING IS INVESTED

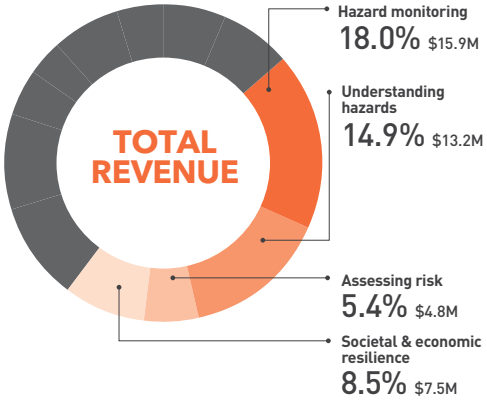
CORE SCIENCE AREA 1:

SCIENCE FOR A CLEANER NEW ZEALAND



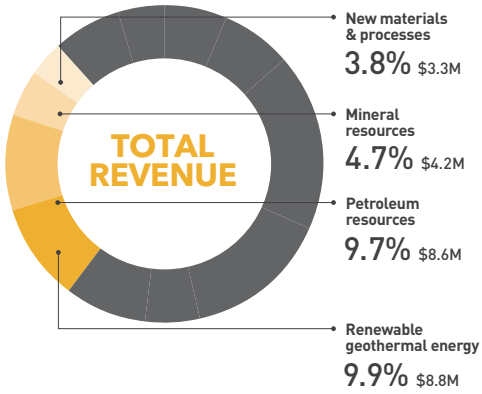
CORE SCIENCE AREA 2:

SCIENCE FOR A SAFER NEW ZEALAND



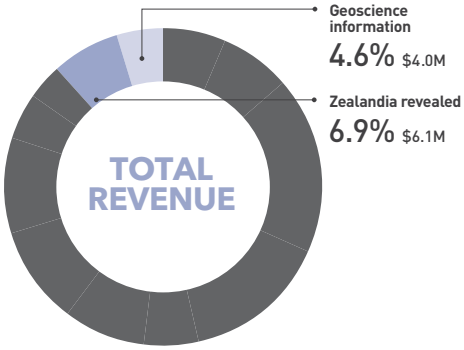
CORE SCIENCE AREA 3:

SCIENCE FOR A MORE PROSPEROUS NEW ZEALAND



CORE SCIENCE AREA 4:

UNDERPINNING GEOSCIENCE KNOWLEDGE



CORE SCIENCE AREA 1:

SCIENCE FOR A CLEANER NEW ZEALAND

We work with local and central government and iwi towards the protection of some of New Zealand's most precious natural resources. Our research and analysis underpins decision-making on the management and protection of our groundwater resources, which make up 35% of the country's freshwater, and the monitoring and mitigation of air pollution in our urban environments. Our internationally acclaimed paleoclimate work is crucial to identifying and preparing for the impacts of climate change.

WORKING IN PARTNERSHIP

Project: Lakes380: Our lakes' health: past, present, future – Me hoki whakamuri kia haere whakamua

Partners: Cawthron Institute, Victoria University of Wellington, University of Otago, The University of Auckland, Kahungungu Ki Wairarapa iwi, Matana Consulting, Northern Arizona University, University of Maine, University of Wisconsin-Madison, University of Adelaide, Griffith University, University of Southampton, University of Regina.

Outline: Co-led by GNS Science and Cawthron Institute, this project will characterise the health of New Zealand lakes by uncovering their environmental history from sediment cores taken from more than 300 lakes. A combination of traditional environmental reconstruction techniques and more recent methods such as environmental DNA and high resolution core scanning will be used. The data will allow us to characterise current lake health and explore causes and rates of change over the last 1000 years. See Lakes380.com

MAKING A GLOBAL CONTRIBUTION IN CLIMATE SCIENCE

Making influential contributions to New Zealand and global science is part of our DNA. Our global reach was underlined late last year with a contribution we made to the World Meteorological Organization's *Greenhouse Gas Bulletin*. Lead radiocarbon researcher Jocelyn Turnbull is one of the authors of the *Bulletin* through her role on the 15-member UN Greenhouse Gas Scientific Advisory Group.

This opened the way for us to submit an article on using Antarctic ice cores to reconstruct atmospheric carbon dioxide levels over the last 55 million years. Having a prominent voice in such a prestigious publication is rare and an indication of the strong reputation our science enjoys on the international stage.

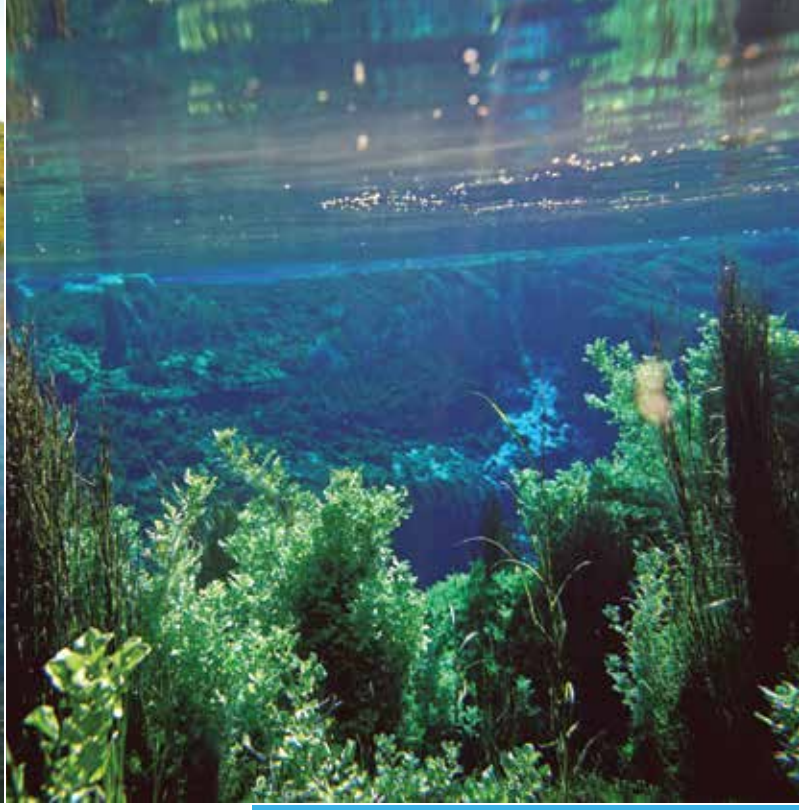
The *Bulletin* itself is read widely throughout the world, and this particular issue received global media coverage. Its headline story reported that the concentration of carbon dioxide had reached a record high of 403ppm in 2016 due to a combination of human activities and the El Niño weather phenomenon.

The figures are collected from weather stations dotted across 51 countries that measure concentrations of warming gases including carbon dioxide, methane and nitrous oxide. The findings published by the WMO are what is left in the atmosphere after significant amounts are absorbed by the Earth's 'sinks', which include the oceans and the biosphere.

The *Bulletin* reported that the rate of increase of atmospheric carbon dioxide over the past 70 years is nearly 100 times greater than at the end of the last ice age. Such abrupt changes have not been seen in the historical record and, according to the *Bulletin*, have the potential to initiate unpredictable changes in the world's climate system.

The accompanying article from GNS Science was written by ice core researcher and leader of the Antarctic Research Platform Nancy Bertler, paleoclimate scientist Richard Levy, and Jocelyn Turnbull. They describe the techniques they use to coax tiny air bubbles in Antarctic ice cores to reveal an intricate record of greenhouse gas concentrations going back up to 700,000 years.

The records derived from the ice cores provide proof that during the last eight interglacial periods in Earth's history, atmospheric carbon dioxide varied between 180 and 280ppm. Today's concentration of 400ppm exceeds the natural variability seen over millennia. The trio say the information obtained from the ice cores provides valuable evidence to assess the environmental and ecosystem responses to high carbon dioxide concentrations which, in turn, helps to ground-truth the models that predict future climate scenarios. GNS Science operates an ice core research facility, one of a handful of such facilities around the world.



A DIGITAL GROUNDWATER ATLAS FOR NEW ZEALAND

Our scientists are part-way through a one-year project to develop New Zealand's first digital Groundwater Atlas, which will contain comprehensive information about this important resource at a national scale. The project output will be a set of publicly available online digital groundwater maps that use nationally-consistent methods to describe our current state of knowledge on groundwater quality, quantity, flows, locations and drinking water security assessments.

Groundwater is an essential part of our environment. It accounts for 26% of New Zealand's drinking water and has an estimated economic value of $2 billion-a-year from irrigation alone. To sustainably manage this resource government needs to know where groundwater is, how much there is, how it moves through aquifers, its quality and any seasonal variations.

The project will unify disparate information about New Zealand's groundwater resources and facilitate improved freshwater management. Much of the information already exists, but it is fragmented and not in a consistent format, so is not readily available for policy development or national-scale environmental reporting.

As the project develops, we will make improvements to the existing information. For example, the 2001 nationally-consistent aquifer map will be updated to produce the first nationally-consistent 2D map of aquifer boundaries since 2014.

GNS Science is leading this project in association with ESR, NIWA, and independent research provider Aqualinc Research Ltd, under a contract with the Ministry for the Environment. Our Hydrogeology group is uniquely placed to lead this work, being responsible for monitoring groundwater quality at the national scale since 1998, and having spent over a decade working on projects that have led up to the development of this initiative.

The Atlas will inform multiple work streams across the Ministry related to legislated requirements for environmental reporting and management of freshwater. This includes allocation, groundwater and surface water interactions and limit setting. It will also increase public awareness about groundwater and help identify information gaps to support future work.

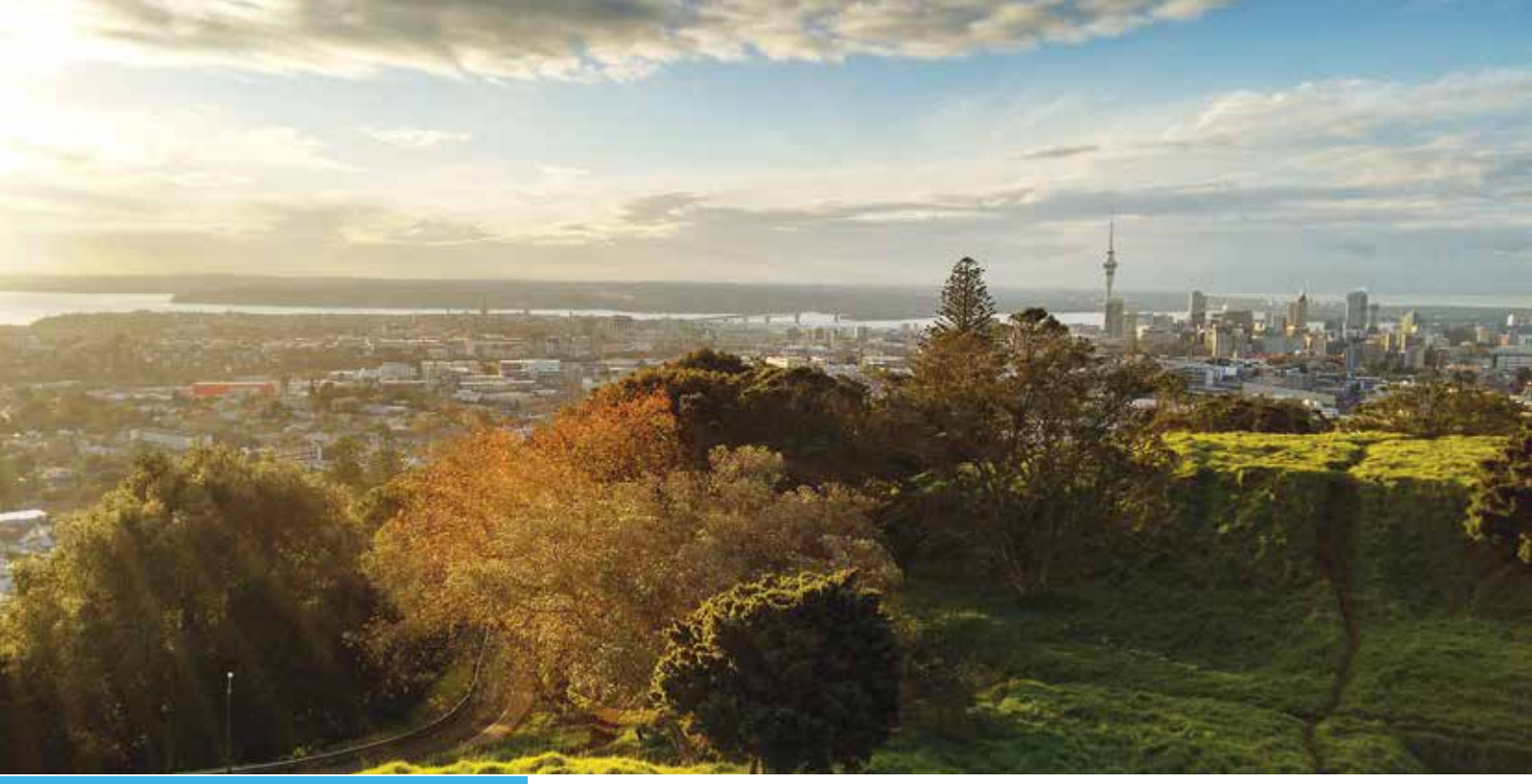
The New Zealand Groundwater Atlas is intended as a first version, with the digital data formats created in anticipation of future updates. We will also make recommendations for additional work or methods needed for updating this information in the future.

WORKING IN PARTNERSHIP

Project: Past climate and environmental studies of the South Pacific and Southern Ocean

Partners: NIWA, New Zealand Antarctic Research Institute, Victoria University of Wellington, International Ocean Discovery Program (USA), Korean Polar Research Institute, Australian National University, JAMSTEC/Kochi University/AIST (Japan), Alfred Wegener Institute (Germany), University of Bordeaux.

Outline: This research heavily relies on the availability of high-quality, deep-sea sediment cores, which are expensive to obtain. To complement the limited capability available at national level, over the last 10 years, we developed international partnerships with world-leading players in this field. This has resulted in several GNS-led projects aimed at improving our understanding of the role of the ocean in environmental and climate change, and how these processes and events affect New Zealand.



WORKING IN PARTNERSHIP

Project: Southern Ocean Atmospheric Radiocarbon (SOAR)

Partners: NIWA and research organisations in Australia and the UK

Outline: The Southern Ocean is the world's largest carbon sink, removing a significant portion of human-produced carbon dioxide from the atmosphere. Yet as the world warms and the westerly winds over the Southern Ocean increase, there is conflicting evidence for how the rate of carbon uptake is responding. This project takes a fresh look at the problem, using existing and new measurements and model simulations of radiocarbon in carbon dioxide above the Southern Ocean to track changes in upwelling of old, deep waters which are thought to be a key control on the rate of carbon uptake.

Project: Smart models for aquifer management

Partners: NIWA, ESR, Victoria University of Wellington, Market Economics, DOC, Landwaterpeople, University of Waikato, Environment Southland, Greater Wellington Regional Council, plus research organisations in Germany and Australia.

Outline: This programme is focused on developing methods to guide decisions on model and data use required for efficient management of New Zealand aquifers. In three case study catchments – Mataura (Southland), Hauraki Plains (Waikato) and Ruamahanga (Wellington) – we are refining the modelling and data selection techniques to ensure they will make a major contribution to more effective water allocation and limit setting.

A CARBON BUDGET FOR AUCKLAND

Auckland will get a full carbon budget in 2019 as a result of a collaborative pilot project that GNS Science is leading. Auckland's Carbon Emissions project, or ACE, will be based on total atmospheric carbon emissions less the amount of carbon being absorbed into the land, giving a net carbon emissions rate for the city.

At this stage, the city's total human-produced emissions are only partly known. Exactly where and when they occur and the uptake of carbon dioxide back into the land is unknown. This pilot study will provide the first city-scale evidence to determine how much atmospheric carbon is being taken in, or removed, by the land in Auckland. The project team comprises GNS Science, NIWA, Auckland Council, The University of Auckland, and Auckland University of Technology.

Assessing the size of New Zealand's 'land carbon sink' will be crucial as the country considers how to get to net zero carbon emissions by 2050. The 'land carbon sink' is the uptake of carbon dioxide by plant growth and subsequent storage of that plant material in the soil. The good news is that it might offset emissions by more than initial estimates.

For the past 18 months, team members have been collecting air samples from 25 sites around Auckland. Analysis includes CO_2 concentration and radiocarbon measurements to determine how much CO_2 is emitted from the burning of fossil fuels and the amount removed by the land carbon sink.

Sites cover a range of areas with several on hilltops and tall buildings that 'see' large areas of the city. There are two 'control' sites on Auckland's west coast to measure the amount of carbon dioxide entering the city on the prevailing westerly wind. The other 23 sites are spread across the city.

An improved understanding of the current levels of carbon emissions and where they are coming from will be needed to enable meaningful reduction measures. This will be one of the few studies in the world using very precise radiocarbon measurements to quantify an urban carbon budget – the volume of fossil fuel emissions and the offsetting 'land carbon credit'.

At present Auckland's knowledge of its fossil fuel emissions – petrol, diesel, natural gas, and coal – is not detailed enough to know how government policies might be influencing emission rates. The aim of this pilot project is to prove the methodology so it can open the way for permanent carbon emission measurements in other New Zealand cities.

MODELS MAY BE UNDERESTIMATING FUTURE GLOBAL WARMING – STUDY

We were part of a global study this year that concluded that many current climate models may be underestimating projected changes within the next 100 years. Published in *Nature Geoscience*, the study concluded that global warming could be up to twice that predicted in models even if the world stays within the 2°C target.

The findings were based on observational evidence from three warm periods during the past 3.5 million years when the world was up to 2°C warmer than the pre-industrial temperatures of the 19th century. The research also revealed how large areas of the polar caps could collapse and there could be significant changes to ecosystems worldwide.

The researchers from 17 countries involved in the study concluded that there were a number of amplifying mechanisms at play in past warm periods that are poorly represented in climate models. This suggests that the carbon budget to avoid 2°C of global warming may be far smaller than estimated, leaving little room for error to meet the Paris Agreement targets.

The researchers pieced together the impact of these warm periods by combining information derived from ice cores, seabed sediment cores, fossil records, analysis of marine micro-organisms, radiometric isotope dating, plus a host of other paleoclimate methods.

To get their results, they examined three of the best documented warm periods – the Holocene thermal maximum (5000-9000 years ago), the last interglacial (129,000-116,000 years ago) and the mid-Pliocene warm period (3.3-3 million years ago). The mid-Pliocene event coincided with atmospheric carbon dioxide concentrations that were 350-450ppm – much the same as today.

The changes to planet Earth under these past warming conditions were profound. There were large retreats of ice sheets from both poles causing sea levels to rise by at least six metres, high latitude species declined, forest species shifted several hundred kilometres towards the poles, and marine ecosystems were dramatically affected. By contrast, planet Earth is warming faster than during any of these past warm periods as carbon dioxide emissions continue to grow.

The researchers concluded that even with just 1.5°C of warming, there would be significant impacts on planet Earth. For instance sea level rise could become unstoppable for many hundreds, or perhaps even thousands of years. They added that if today's leaders don't act with purpose to address greenhouse gas emissions, global warming will bring profound changes to our way of life.

WORKING IN PARTNERSHIP

Project: Early Eocene super-warm climates

Partners: University of Bristol, Lamont-Doherty Earth Observatory, University of California Santa Cruz, Victoria University of Wellington, Purdue Climate Change Research Centre, University of Adelaide

Outline: This project is investigating to what extent New Zealand temperatures warmed under the high atmospheric CO_2 concentrations (about 1000ppm) that existed in the early Eocene (56 to 48 million years ago). This is akin to concentrations that may be reached by the end of 2100 if the IPCC worst case scenario (RCP8.5) eventuates. GNS Science expertise in paleontology and stratigraphy has been combined with expertise in geochemistry and plant taxonomy from overseas collaborators.

Project: Roosevelt Island Climate Evolution (RICE) project

Partners: More than 70 scientists from 12 countries, including New Zealand partners Victoria University of Wellington, University of Waikato, and Antarctica New Zealand

Outline: A landmark NZ-led multi-year international project that has recovered nearly 800m of ice core from Antarctica to learn more about how Antarctica will respond to a warming world with the potential for rapid sea level rise. Detailed analysis of the cores, stored at GNS Science's Ice Core Facility, has revealed year-by-year climate changes for millennia. Findings are feeding into global climate models and government policy decisions on climate adaptation.

CORE SCIENCE AREA 2:

SCIENCE FOR A SAFER NEW ZEALAND

As our population grows in number and density, so does the level of risk from the natural hazards that are an intrinsic part of our environment. Our work in better understanding these hazards helps develop priorities and shape decisions to improve disaster preparedness and reduce the economic and social costs of earthquakes, tsunamis, volcanic eruptions, and landslides.

REDUCING THE THREAT FROM LANDSLIDES

We are leading a multi-national project to develop new ways of managing the risks that landslides pose to people and infrastructure. The five-year programme is based on analysis of the tens of thousands of landslides caused by the magnitude 7.8 Kaikōura earthquake of November 2016, and the results will be applicable to other regions in New Zealand and overseas.

The main benefit from this research will be improved resilience of New Zealand's homes and infrastructure leading to the ability to avoid costs and trauma from prolonged earthquake-induced landsliding. It will also enable the risks from landslide and sediment hazards to be effectively managed.

The Kaikōura earthquake generated tens of thousands of landslides over an area of about 10,000 km^2. While landslides cost New Zealand an average of $300 million a year, Kaikōura was an exception. The rebuilding of State Highway 1 and the Canterbury-Picton rail line cost in excess of $1 billion, tourism revenue was affected and freight costs were pushed up sharply by the diversion of Christchurch-Picton road and rail traffic.

Longer-term effects of sediment aggradation – where the debris moves downstream from the steeper in-land slopes to the sea – caused another cascading hazard that posed flooding threats to farms and infrastructure. These hazards could persist for years, and possibly decades, and represent a prolonged risk that needs to be managed.

One of the goals of the work is to quantify how long a landscape takes to 'heal' after a major event such as the Kaikōura earthquake. One year into the programme, outputs are already starting to be applied in informing transport infrastructure route selection, land-use planning, and emergency response. Internationally, where investment has been made in improving slope practices, there are tangible benefits. Improved slope management practices in Hong Kong have reduced landslide risk by around 50% between 1977 and 2000.

Sectors that will benefit from this programme include emergency response and preparedness, land-use planning, infrastructure planning, the insurance industry, catchment management, river control works, and landslide forecasts and alerts. GNS Science leads this initiative with support from specialists from Auckland, Massey, and Victoria Universities, Durham University, Kyoto University, the University of Rennes, Simon Fraser University, and Opus International Consultants.

WORKING IN PARTNERSHIP

Project: Emerging Anthropogenic Slope Hazards

Partners: Aurecon NZ Ltd, Wellington City Council, Wellington Water, NZ Transport Agency, TTAC Ltd (UK)

Outline: This project aims to firstly assess the performance of anthropogenic slopes in central Wellington under earthquake shaking and rain events, or due to a combination of both factors. It will then attempt to improve the resilience of New Zealand's infrastructure through better knowledge of the behaviour of anthropogenic slopes and develop strategies for more robust remediation approaches. Findings will be applicable to slopes throughout New Zealand.

Project: Quicker and safer tsunami evacuations through agent-based modelling

Partners: Massey University, University of Canterbury, East Coast LAB

Outline: This project aims to develop a software package that simulates how people respond to a tsunami evacuation warning. It factors in the numerous influences on people's movements during an evacuation event. The work is focusing on three coastal locations – Petone, Sumner, and Tolaga Bay. The project will improve the ability of emergency managers to prepare a population for tsunami events and upgrade tsunami evacuation infrastructure.

WORKING IN PARTNERSHIP

Project: **Hikurangi Subduction earthquakes and slip behaviour**

Partners: NIWA, Victoria University of Wellington, University of Otago, The University of Auckland, Massey University, University of Canterbury, East Coast LAB, and partners from over a dozen universities in the United States, Japan, and the United Kingdom

Outline: This GNS Science-led project supported by the MBIE Endeavour Fund uses offshore and onshore geological and geophysical data to reveal the history of past earthquakes on the Hikurangi Subduction zone, and the modern-day fault slip behaviour of the offshore portion of the plate boundary where tsunamis are typically generated. Seismic imaging and scientific drilling at the offshore plate boundary will reveal the physical processes that control earthquake and tsunami occurrence at the Hikurangi Subduction zone. Mātauranga Māori will also help to discern the human impacts from past Hikurangi earthquakes. Findings will have international implications and will help planners and emergency response agencies be better prepared for large earthquakes and tsunamis.

Project: **Kaikōura landslide project**

Partners: Auckland, Massey, and Victoria Universities, Durham University, Kyoto University, the University of Rennes, Opus International Consultants, and Simon Fraser University

Outline: A five-year investigation of the thousands of landslides triggered by the 2016 magnitude 7.8 Kaikōura earthquake to develop new ways to manage the risks that landslides pose to people and infrastructure. The main benefit will be improved resilience of New Zealand's homes and infrastructure leading to the ability to avoid costs and trauma from prolonged earthquake-induced landsliding.

Project: Planetary degassing: A study of how gases are released from New Zealand's subduction system and their impact on Earth's atmosphere

Partners: Lehigh University USA, and The University of Tokyo

Outline: Funded by the National Science Foundation in the US, the University of Tokyo and GNS Science, this multi-year project is investigating the cycling of volatiles such as water vapour, carbon dioxide and nitrogen at New Zealand's plate boundary. The aim is to reduce the large uncertainties as to the quantities of volatiles that are taken into the mantle by subduction versus those that are recycled and released into the atmosphere. The findings will have international implications.

EARTHQUAKE RISK ASSESSMENT OF ROTORUA'S WATER NETWORKS

With the help of GNS Science, Rotorua City is taking steps increase the resilience of its sub-surface infrastructure to the impacts of a damaging earthquake in the region. We recently completed an earthquake risk assessment of Rotorua's water supply and wastewater networks to identify vulnerable parts of the underground infrastructure.

Based on our knowledge of the region's geology and hazards, we chose a credible earthquake scenario for the study. Of the known active faults within 50km of the city, Ngakuru Southwest fault has the largest contribution to probabilistic seismic hazard in the region. This fault has a characteristic earthquake of magnitude 6.0 and a return interval of 970 years.

The City's water supply network includes intakes, pump stations, reservoirs, and underground pipes. The wastewater network has pump stations and pipes. Together they represent a multi-million dollar asset. Observations of damage to subsurface infrastructure during the 2010-2011 Canterbury earthquake sequence informed our modelling. For Rotorua, we considered ground-shaking, liquefaction, and lateral spreading hazards in our calculations.

The damage modelling estimated failure points in water supply pipes and the wastewater network across the district. We estimated outage times based on the number of crews and repair rates available under current operating conditions. This exercise helps to provide a sense of relative severity of outages among different supply zones and catchment zones. We estimated dollar losses using average repair costs for failed components of the network.

"Estimating earthquake effects on water networks is a multi-disciplinary challenge. We meticulously model the hazard, ground damage and engineering performance of the network to offer realistic estimation of service outage to help the Council in their resilience planning."
Dr SR Uma, Earthquake Engineer

The project has provided the Council with new insights in terms of dollar losses and duration of water and wastewater outages as a result of a damaging earthquake. Even though these estimates can be influenced by many uncertainties, the findings from this study will help with short, medium, and long-term planning for managing the City's assets. Our report includes a series of outage maps which are a powerful means of communicating the risks to stakeholders and the public.

Following this initial study, we have recommended that the Council does risk assessments for road, electricity and fuel networks, and reviews protocols for engaging with the local population to improve community resilience.

DUNEDIN STUDY SETS BASELINE FOR URBAN FAULT INVESTIGATIONS

A GNS Science-led investigation of a handful of active faults in the wider Dunedin area has a mix of good and bad news for the city. While the overall seismic hazard of the city is unchanged, one of the faults extends closer to the city than previously thought and a couple of new fault sources were uncovered. However, the 'new' fault sources described in the study have been assigned a low level of activity and therefore don't alter the overall hazard profile of the city.

Importantly, the pilot study has shown the worth of a portfolio of scientific techniques for elucidating the threat from previously unknown and poorly known faults near our cities.

The study in Dunedin follows a recommendation from the Canterbury Earthquakes Royal Commission for more research to paint a better picture of the quake risk faced by population centres. Dunedin was chosen for this initial study because active faults that were already known could potentially extend under the city, and it is a compact city where local scientists are already working on earthquake research. In addition, Dunedin has similar heritage buildings to Christchurch.

The study probed the sub-surface both on land and off the Dunedin coast.

Scientists used a suite of techniques including conventional geological studies, geophysical techniques, GPS, satellite imagery, and deployment of seismometers.

A better understanding of the presence of active faults beneath, and close to, our cities is important for land-use planning, risk management, and emergency response activities. The study has provided a baseline for Dunedin that should be reviewed as new data becomes available, including GPS data from new sites set up as part of this study.

The study makes a range of recommendations for future work in the Dunedin region including more GPS data, satellite imagery, offshore and onshore geophysical studies, and further physical probing of known faults to better understand fault behaviour. Study findings will be incorporated into planning and policy development in a number of organisations to make Dunedin safer.

The study team comprised 18 researchers from GNS Science, the University of Otago, and the Geological Survey of Spain. It was funded jointly by the National Hazards Research Platform, GNS Science, the University of Otago, and the Earthquake Commission.

WORKING IN PARTNERSHIP

Project: The probabilities of large earthquakes in central New Zealand

Partners: University of Otago, The University of Auckland, Victoria University of Wellington, University of California Santa Cruz, US Geological Survey, Lamont-Doherty Earth Observatory, National Central University Taiwan, National Institute of Geophysics and Volcanology Italy, University of Southern California, University of Washington, The University of Tokyo.

Outline: One of the numerous initiatives in the wake of the 2016 M7.8 Kaikōura earthquake, this project developed new earthquake forecasting models for central New Zealand that incorporated the influence of slow-slip episodes occurring on the Hikurangi Subduction zone. Estimating how slow-slip events can influence the likelihood of future earthquakes is a world first for this area of science. These forecasts are focused on larger magnitude quakes, rather than just the Kaikōura aftershock sequence.

Project: Eruption or Catastrophe: Learning to Implement Preparedness for future Supervolcano Eruptions – ECLIPSE.

Partners: Victoria University of Wellington, Massey University, iwi, local communities, the Caldera Advisory Group including Waikato and Bay of Plenty Civil Defence, Ministry of Civil Defence and Emergency Management, EQC, University of Canterbury, The University of Auckland, and Waikato University.

Outline: A project aimed at better preparing New Zealand for future eruptions by the central North Island supervolcano complex. Partners are working with central North Island communities to help them understand uncertainties in the science of forecasting eruption events, as well as helping them better prepare for such emergencies.

EXPERT HELP FOR PACIFIC NEIGHBOURS

GNS Science and collaborating New Zealand volcanologists are supporting two drawn-out high-profile Pacific eruptions – Ambae in Vanuatu and Kilauea in Hawai'i. Over the past 20 years, New Zealand has developed a world-leading research programme on volcanic impacts, particularly relating to infrastructure, agriculture, and health. This expertise has made New Zealand a valued partner during eruption responses.

Ambae Island hosts one of a handful of Vanuatu's active volcanoes, which has led to two phases of evacuation in the past 12 months. Between March and June this year, volcanologists from GNS Science, the University of Canterbury, and the Joint Centre For Disaster Research at Massey University provided in-country support on dealing with impacts of the eruption to the Vanuatu Government through MFAT's New Zealand Aid Programme. This involved working closely with the Geohazards Division of the Vanuatu Meteorology and Geohazard Department.

In addition, New Zealand also provided remote support by undertaking laboratory work to assess ash and drinking water samples. Our team has supported the development of key messages for volcanic gas and ash, acid rain, roof cleaning, and roof collapse potential. We have also supported scientists in Vanuatu with their monitoring activities since the eruption started in September 2017.

In July and August these teams, joined by others from Auckland, Canterbury, Otago and Massey Universities and the Earth Observatory of Singapore, carried out detailed research into the workings of the ongoing eruption, from the magma through to the ash. This is GNS Science-coordinated research, funded by each agency's research programmes – rather than humanitarian work – and is in collaboration with local Vanuatu scientists. What we learn and publish from this eruption will help us be better prepared for future eruptions in New Zealand.

The Kilauea eruption, with concurrent activity at the Halema'uma'u summit crater and on the East Rift Zone of Hawai'i, has received considerable media attention. Behind the scenes, New Zealand volcanologists at GNS Science, Canterbury University and the Joint Centre for Disaster Research have maintained and updated the US Geological Survey-hosted Volcanic Ash Impacts and Mitigation webpage, helped interpret data, and answered questions from the public about how best to deal with volcanic ash.

Both eruptions have been difficult and testing for local communities. New Zealand's investment in researching volcanic impacts has directly assisted with the response to both eruptions. These eruptions also provide valuable lessons that will help New Zealand when we in turn are faced with a local disruptive and damaging volcanic eruption.

WORKING IN PARTNERSHIP

Project: The Wellington Regional Resilience Project

Partners: Wellington Lifelines Group (Wellington Water, Transpower, Wellington City Council, Hutt City Council, Porirua City Council, Upper Hutt City Council, Kāpiti Coast District Council, Greater Wellington Regional Council, New Zealand Transport Agency, KiwiRail, CentrePort Wellington, Wellington Electricity, Nova Energy, Powerco, Electra), Market Economics Ltd, Resilient Organisations Ltd, and Aurecon Ltd.

Outline: This multi-year project pools the efforts of science and engineering organisations, infrastructure providers, and regional and local councils with the aim of increasing the resilience of Wellington's infrastructure to earthquakes. It builds on many years of work in Earth science, hazard and risk analysis, and economic modelling to develop a sound case for strengthening the resilience of our infrastructure to reduce the impacts and costs of a damaging earthquake in the region.

Project: Gravity changes in northern South Island

Partners: Land Information New Zealand, Kyoto University, Geoscience Australia

Outline: This project aims to find the effect of the 2016 M7.8 Kaikōura earthquake on the gravity field of the northern South Island. This is important because mass changes in the Earth associated with large earthquakes affect the geoid – the reference that is widely used by surveyors, councils and utilities for planning and engineering projects. Several hundred observations were made across the upper South Island with highly sensitive instruments. The data will be incorporated into models to show the impact of the earthquake on the geoid.

Project: Measuring the Economics of Resilient Infrastructure Tool (MERIT) – www.merit.org.nz

Partners: Resilient Organisations Ltd, Market Economics Ltd

Outline: This project has developed a world-class decision support tool called MERIT that enables users to value improvements in infrastructure resilience, and to assess the economic implications of infrastructure recovery decisions during disasters and major disruptive events. MERIT incorporates an advanced economic modelling approach that can model the complex interactions and feedback loops that occur in economic systems, based on the effects of outages to critical infrastructure systems. MERIT maps the effects to the New Zealand economy regionally or nationally, and has been used successfully by government and infrastructure agencies.

CORE SCIENCE AREA 3:

SCIENCE FOR A MORE PROSPEROUS NEW ZEALAND

New Zealand's natural resources offer significant opportunities for prosperity and energy security. Our work is central to the ongoing viability of our geothermal energy capability, a clean, reliable and cost-effective energy source that makes up 17% of New Zealand's energy generating capacity. New Zealand is rich in oil and gas, gas hydrates, and other minerals – our research and analysis enable sound decision-making around the management and protection of these valuable resources. We also have a specialist capability in isotope and ion beam technologies that offers the potential for high value benefits to industry.

WORKING IN PARTNERSHIP

Project: Mineral Exploration Models

Partners: The University of Auckland, University of Waikato, University of Otago

Outline: This GNS Science-led project combines the talents of our scientists with the Universities of Auckland, Waikato and Otago, as well as overseas collaborators. It has also involved mineral exploration and mining companies who provided access to prospects and their exploration information. The results to date have been published in scientific journals, reports and databases, presented at major scientific and minerals industry conferences and workshops, with an emphasis on supporting industry to use the new information in their exploration programmes.

Project: Magnetotelluric Survey of the Wairakei-Tauhara Geothermal Field

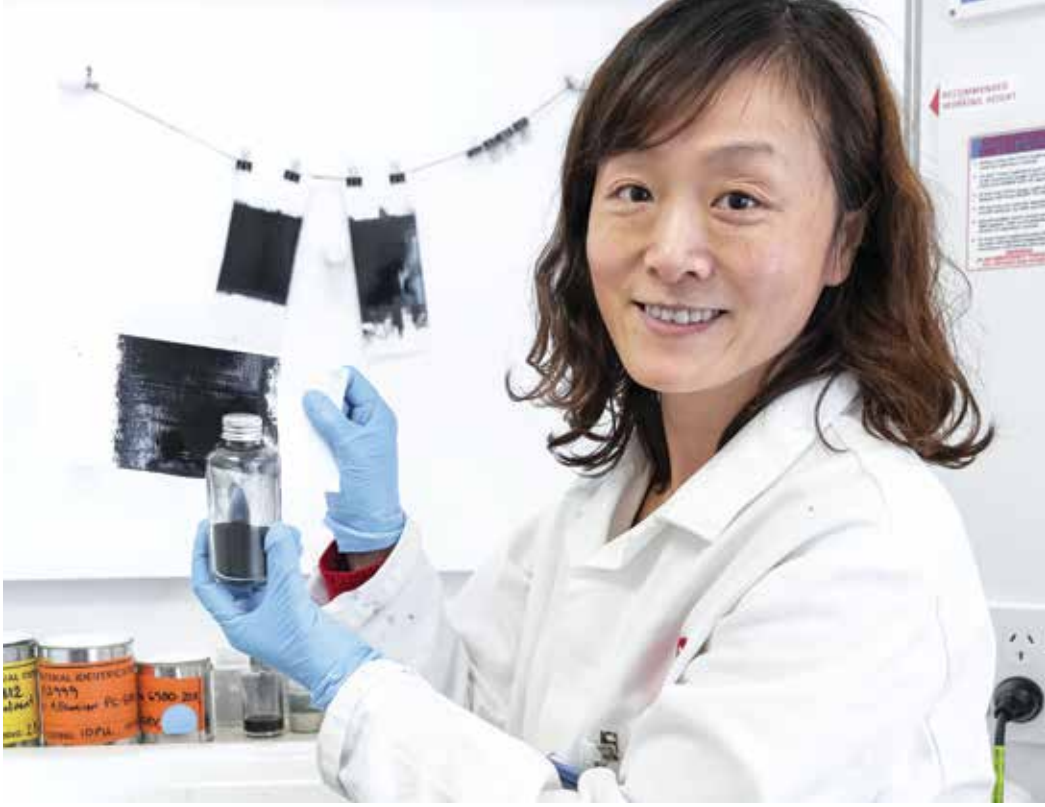
Partner: Contact Energy

Outline: Collaborative co-funded research to measure regional magnetotelluric (MT) data and integrate with local MT data (provided by Contact Energy), to generate a 3D resistivity model of the Wairakei-Tauhara geothermal field. This will inform the deep resource potential of the geothermal system, and support mid and long-term resource management strategies for the field operator. MT is a geophysical technique that can detect fluids in the sub-surface.

Project: Wood Energy Industrial Symbiosis

Partners: Scion (Project Lead) and University of Waikato

Outline: This four-year MBIE-funded project aims to identify opportunities for industrial clustering of wood resources, natural renewable energy sources, and process heat demand in the one place for mutual advantage. For example, wastes and by-products from one facility can become the raw material for another. The project is co-funded by EECA, Oji Fibre Solutions, Sequal Lumber, Norske Skog, HRL Morrisons, Kawerau District Council, Ngāti Tuwharetoa Geothermal Assets, Bay of Connections, Carter Holt Harvey Pulp & Paper Ltd, and Grow Rotorua.



NOVEL SOLUTION TO NEW COOL BLACK COATINGS

Our Materials group is making steady progress towards its goal of developing novel composite materials for use in 'cool black' coatings to help reduce costs of cooling buildings and extend the life of building materials. Black surfaces strongly absorb solar energy, become overheated and can be prone to fast deterioration. The aim of this two-year MBIE-funded project is to make a black pigment material that strongly reflects infra-red light and can be incorporated readily into paints and cladding materials.

"The colour black isn't something that pairs well with the summer heat. With the new cool black pigments we are developing, we will be able to increase lifespans of black surfaces, reduce energy costs for cooling buildings, and reduce greenhouse gas and pollution emissions."
Dr Vivian Fang, Nanoelectronics Scientist

The trick has been to come up with a pigment that has a low cost of production, is chemically stable, has high solar reflectance, is non-toxic, and is suited to industrial-scale production.

Our Materials group has mastered the first step of designing and making a novel black pigment. Using equipment in our Nano Fabrication Laboratory they have produced a black metal oxide powder from a pure metal raw material. One of the features of the powder is the range in size of the particles from nano-scale to micro-scale. While the powder shows encouraging properties, the acid test will be how this translates into a commercial-grade paint.

In the next phase of the project we will work closely with Resene Paints Limited on validating the thermal and optical properties of the pigment in black industrial surfaces. Resene have been supporting the project from the outset.

The long-term aim is to open the way for inexpensive production of black pigment material to accelerate the development of cool black surfaces. This will result in longer life of building materials, lower maintenance costs, and lower energy consumption for cooling with flow-on positive environmental impacts.

In 2018, the global paint and coating market was valued at $US128 billion, and is forecast to grow by 3% annually. Industry commentators estimate that a cool black paint would increase New Zealand's paint exports by more than $200 million-a-year within five years of becoming available on the market.

POWERFUL SUPPORT FOR GEOTHERMAL ENERGY INDUSTRY

Among the specialist services we provide to the geothermal energy industry is our high temperature and pressure flow simulator which replicates conditions at depths up to 4km below the surface. As the only such facility in the Southern Hemisphere, it is a powerful tool for geothermal operators wanting to better understand the sub-surface environments in which they operate.

About the size of two large suitcases, the simulator is used to study chemical reactions between any water-based fluid and solid material – typically rock. Commonly it is used to predict the effects of fluid re-injection on geothermal reservoirs, and test the effectiveness of compounds added to water to prevent scaling (clogging deposits inside pipes) and corrosion inside geothermal power plants.

It operates at temperatures up to 400 degrees Celsius and at pressures up to 500 atmospheres – equivalent to 5km below the sea. This covers temperature and pressure conditions in most geothermal systems around the world.

While geothermal simulations form the bulk of the work, the facility is also used to investigate the formation of mineral deposits and physical and chemical reactions under the seafloor at mid-ocean ridges.

Findings from the facility help power station operators increase efficiencies and reduce running costs. We also test materials under high temperatures and pressures to help operators chose the best materials for different parts of their power plants. As well as our New Zealand clients, we undertake work for geothermal operators in Japan, the Philippines, and the United States.

"New Zealand is one of a few countries blessed with high temperature geothermal resources. In our drive towards 100 percent green energy and zero carbon emissions, geothermal technologies will play a pivotal role. Being able to simulate reactions deep in the subsurface and in power stations advances our ability to use geothermal resources more sustainably and efficiently."
Dr Bruce Mountain, Senior Scientist

We plan to upgrade the facility in the near future so it can reproduce underground temperatures of up to 700 degrees Celsius. This will enable us to simulate conditions deeper in the Earth's crust such as in geothermal fields in Iceland and in magma bodies inside volcanoes. This will increase its versatility and its usefulness to clients.

WORKING IN PARTNERSHIP

Project: Gas Hydrates: economic opportunities and environmental implications

Partners: NIWA, The University of Auckland, University of Otago, Elemental Group, GEOMAR (Germany)

Outline: This GNS Science-led project aims to address two key research questions: "Will feasible hydrocarbon production scenarios, either directly from gas hydrates or through gas hydrates, significantly impact seafloor stability, ecology or ocean biogeochemistry?" and "What are the likely socioeconomic implications of gas hydrate production in New Zealand?" By investigating environmental impacts and socioeconomic implications of gas production, GNS Science will establish a framework for a balanced risk-benefit assessment of extraction of gas hydrate resources that will inform government policy and regulations.

Project: Understanding petroleum source rocks, fluids, and plumbing systems in New Zealand sedimentary basins

Partners: Auckland, Canterbury, Otago, and Victoria Universities, ESR, Durham University, RWTH Aachen University, Stanford University, University College Dublin, and University of Oxford.

Outline: This research programme is developing valuable new insights into oil and gas occurrence in New Zealand's established and frontier basins through integrated studies of petroleum source rocks, fluids, and subsurface fluid migration (plumbing) systems. The results will provide critical knowledge to help explorers to more effectively predict, target and find new petroleum fields. The programme is being undertaken in partnership with exploration and production companies that are providing access to confidential 3D seismic reflection data volumes, exploration well data and samples, and co-funding.

WORKING IN PARTNERSHIP

Project: Novel inorganic composites for strong near infrared reflecting black coatings

Partners: Victoria University of Wellington, Callaghan Innovation, Resene Paints Ltd

Outline: With our partners, we are developing novel pigment materials for weather, temperature and chemical resistive cool black coatings. This will enable a new industry in New Zealand to be established to make these materials to meet the future demand for cool black surfaces. Companies including high-value manufacturers, investors and Māori-owned businesses in New Zealand will benefit from this work as partners in the supply chain.

Project: Development of inductive power transfer pavement systems for electric vehicles

Partners: The University of Auckland, Victoria University of Wellington, CRL Energy, NZ Transport Agency

Outline: This project aims to develop new technologies that will enable the deployment of Inductive Power Transfer pavement systems for the operation of electric vehicles. Within this large collaboration, the GNS Science team is developing new magnetic composite materials that will be central to the operation of these systems. Current materials available for this purpose are too brittle and may suffer from cracks when continuously exposed to harsh road pavement conditions.

THE PROMISE OF 'CLEAN-TECH' MINERALS

New Zealand could become a producer of high value 'clean-tech' minerals to support a low carbon future, a study by GNS Science has found. A key feature of the study is a series of mineral potential maps that will enable follow up studies that target areas of interest in greater detail.

'Clean-tech' minerals are metals that have many uses in modern society including electric vehicles, wind turbines, aerospace components, consumer electronics, steel and glass additives, sonar systems, batteries, and ceramics.

Our study is the first of its type in New Zealand focusing on the potential for lithium, nickel, cobalt, and rare earth elements. Rare earth elements are a group of 17 elements in the Periodic Table that are increasingly in demand for low carbon technologies. Funded by the Ministry of Business, Innovation and Employment, the study showed many areas are prospective for these minerals in the South and North Islands, although more data is needed to realise the potential of this endowment.

The study was done largely with existing data, but involved innovative techniques to glean optimal value from the information. We also had rock samples from our National Petrology Reference Collection and beach sands, kindly supplied by Hardies Resources, analysed for 54 elements as part of this project. This data added substantially to the completeness of the study.

New Zealand has a reputational advantage within the minerals sector due to its high environmental and health and safety standards. If economic deposits of 'clean-tech' minerals are found here, we have the potential to provide high-quality, ethically and sustainably derived metals that will fetch a premium on world markets.

"These 'clean-tech' mineral potential maps are the first of their kind to be produced for New Zealand and provide a national framework of the potential scale and distribution of our 'clean-tech' mineral resource. Results from this study are already being used as a decision-making tool by government, and may help attract new exploration investment."
Dr Rose Turnbull, Geologist

The study took six months to compile and involved contributions from six scientists. It provides a strong basis to inform decisions on future actions in this area. In the medium term we are aiming to obtain an improved understanding of all of New Zealand's strategic minerals through further targeted research programmes, spatial modelling, and field work. The latter will include sampling of rock chips and soils for geochemical analysis.

A NEW ATLAS OF OUR OFFSHORE SEDIMENTARY BASINS

We have produced a series of new map-based geological data products that will help users understand the geology and history of New Zealand's 17 offshore sedimentary basins. Available freely in workstation-ready formats, the digital Atlas of Petroleum Prospectivity provides detailed information on large areas of the submerged continent of Zealandia.

The output of a four-year MBIE-funded programme, the Atlas provides the most up-to-date understanding of the sedimentary architecture within New Zealand's offshore basins, and the resources they may contain, in a standardised ESRI ArcGIS format. This is the first time such a unified approach has been applied to the numerous offshore basins that make up much of the continent of Zealandia.

The programme has developed new and innovative approaches to the compilation, assessment, visualisation and delivery of big data. It brings together six decades of geoscience information, augmented by new 'open-file' petroleum industry data, on sedimentary basin structure, basin fill and subsurface habitats where oil and gas could potentially have accumulated.

"More than 15 scientists have directly contributed to the Atlas of Petroleum Prospectivity. It is the most comprehensive and feature-rich source of regional-scale geoscience information on our offshore sedimentary basins to date. It will be the go-to compendium for a wide range of stakeholders."
Dr Kyle Bland, Senior Geologist

Datapacks are available through GNS Science's upgraded Petroleum Basin Explorer web portal and via the annual datapack release from New Zealand Petroleum and Minerals. There has been extensive international uptake of the Atlas datapacks as they have been released throughout the four-year programme.

The main users of the atlas are local and international companies that are evaluating petroleum prospects, specialist providers who service the exploration industry, and government agencies that administer permit allocations. There has also been considerable uptake from international universities using these extensive datasets for analogue purposes to help understand other parts of the world, as well as for teaching and training exercises.

One of the developments of the programme is an innovative approach to visualisation and delivery of large volumes of geospatial data. The challenge of publishing the data-dense Atlas maps involving 450-plus layers of information has driven advances in the tools GNS Science uses for web delivery. We can now reproduce the hundreds of layers from an ESRI ArcGIS map file in our webtool PBE in a matter of hours, including the migration of data to corporate servers. Such capability enhancements will have a positive impact on research at GNS Science in areas such as 'Understanding Zealandia' and in groundwater research, as well as the commercial projects we undertake for a variety of clients. This will improve our ability to deliver easily discoverable and searchable science that strongly benefits New Zealand.

CORE SCIENCE AREA 4:

UNDERPINNING GEOSCIENCE KNOWLEDGE

Our role is to improve the understanding of the Earth and its processes, and to manage and make available to a wide range of end-users the information, data and collections we have gathered and analysed to support decision-making by local and central government, communities and businesses. A central focus is exploring and mapping the geological history, structure and processes of the vast undersea continent of Zealandia, much of which remains unexplored.

BUILDING OUR GEOLOGICAL MAP LEGACY

Properly compiled and archived geoscience information can be valuable for decades, if not centuries. It is our role to collect, distill, enhance and curate Earth science data and make the resulting information accessible to a wide range of decision-makers such as government agencies, industry, consultants and communities as well as supporting further research.

One of the quiet achievers in this space is the Geological Map of New Zealand collection. It is one of eight Nationally Significant Collections and Databases we look after. The others include samples and information on rocks, fossils, groundwater, earthquakes, volcanoes and measurements of the Earth's magnetic field.

The geological map collection includes a large number of New Zealand and some Antarctic maps and map products going back to 1865. Geological maps show the surface distribution of geological units and dominant rock types, boundary types including faults, folds and many other features. They range from small scale maps showing wide areas of the country, suitable for a national overview. Large scale maps concentrate on smaller areas of the country such as districts or cities and have more technical detail.

All are publicly accessible and are mostly available as one or more of conventional printed maps, digital images, GIS data, and as downloadable maps. Three of our five new geological maps since 2012 are digital-only with printing reserved for those of special and widespread interest. This includes the recently published 1:1 million-scale Geological Map of New Zealand (as North Island and South Island sheets) and the 1:60,000 geological map of Tongariro National Park.

The digital maps are interactive and web-enabled, designed for use with specialist GIS software. Historic maps, including many unpublished field sheets containing valuable observations, have been scanned and are available for download.

Our 2015 urban Christchurch and eastern Canterbury map product is the first to include 3D geological and geotechnical models. More will follow, including the 3D geological model of Napier-Hastings in 2019. Three-dimensional urban geological maps use drill hole information to show subsurface as well as surface variation in rock types. They offer more detail for planning purposes and geotechnical assessments. They also help with groundwater management and assessment of quarry resources.

WORKING IN PARTNERSHIP

Project: Geological Map of Antarctica

Partners: An 'Action Group' of the Scientific Committee on Antarctic Research 'GeoMAP' comprising 35 people from 15 nations.

Outline: GNS Science is leading this international project to build a modern digital geological map of Antarctica that describes the bedrock and surficial geology of the Continent. The aim of this massive undertaking is to build a highly comprehensive, versatile, and user-friendly geological map of Antarctica that will function like a 'Wikipedia' of Antarctic geology. The map will provide valuable new insights into the evolution and makeup of Antarctica. An early version is expected to be ready in the first quarter of calendar 2019.

Project: Tongariro National Park Geological Map

Partners: Department of Conservation and Victoria University of Wellington

Outline: This collaborative project has produced a detailed 1:60,000 scale geological map of the Tongariro National Park with substantial improvements on previous maps of this area. It describes the geological history and structure of all the volcanoes in the park. The product consists of a large colourful map, a companion book, and associated digital data in various forms. It is aimed at the public and can also be used as a basis for further scientific studies. The Tongariro National Park is the world's fifth oldest national park and is designated as a dual UNESCO World Heritage Area.

SCIENCE FOR A CLEANER NEW ZEALAND

IMPACTS AND MEASURES AS ENVISIONED IN OUR 2017 STATEMENT OF CORPORATE INTENT

CORE SCIENCE AREA	IMPACT AREA	IMPACTS AND MEASURES OF SUCCESS	PROGRESS/ACHIEVEMENT
Relates to SCP Outcome 5: Increase understanding of the geology and past climates of New Zealand, the Ross Dependency and Antarctica	Past, Present, and Future Climates **SCI Impacts 1, 2, 3**	More-robust model predictions; Enhanced mitigation and adaptation strategies; Increased international research leverage By 2018, our scientists are fully engaged in the process leading to the next IPCC report, and are providing key paleoclimate information from the SW Pacific, Antarctica and New Zealand, published in high-impact international journals.	Several leading papers co-authored by GNS Science staff show our continued close involvement with IPCC activities. 'Paleoclimate constraints on a world with post-industrial warming of 2 degrees and beyond', accepted by *Nature Geoscience*, brings together ice core, climate modelling, and paleo-oceanography expertise in a state-of-knowledge summary aimed for inclusion in the next IPCC report. The paper is highly relevant to the Paris Agreement targets, outlining what could happen to a variety of ecosystems and processes in the context of global warming. A preliminary report for the IODP Ross Sea expedition (Leg 374) to assess West Antarctic ice sheet history describes Neogene sedimentary sequences along a shelf to basin transect. It elucidates fundamental climate system processes, some of which are poorly constrained by climate models. These processes include the interaction between the ocean and polar ice-sheets, Antarctica's contribution to sea level rise, evidence for past polar amplification, and the sensitivity of Antarctic Ice Sheet mass balance during warmer-than-present climates.
Relates to SCP Outcome 5: Increase understanding of the geology and past climates of New Zealand, the Ross Dependency and Antarctica	Past, Present, and Future Climates **SCI Impacts 2, 3**	Enhanced mitigation and adaptation strategies; Increased international research leverage By 2018, carbon source and sink data are included in New Zealand emissions reporting, and used to inform international advisory groups such as IPCC, WEF, and the WMO.	The carbon source and sink methodologies developed for New Zealand and the world are included in the World Meteorological Organization's new program, the Integrated Global Greenhouse Gas Information System (IG3IS), for which GNS Science's Jocelyn Turnbull is a lead author. IG3IS provides guidelines for integrating atmospheric greenhouse gas information with more traditional inventory-based reporting techniques. It is being incorporated into the 2019 revision of the IPCC Task Force on National Greenhouse Gas Inventories. This documents how nations should report their greenhouse gas inventories under the Paris Agreement. Our research contributes directly to the WMO's Global Atmospheric Watch program. The Scientific Advisory Group, of which Turnbull is a member, produces an annual 'Greenhouse Gas Bulletin' which assesses global greenhouse gas emissions for general and policy audiences. The 2017 bulletin, reported in the international media more than 3000 times, included an article by GNS Science researchers Bertler, Levy, and Turnbull on 'Discovery of ancient atmospheres in Antarctic ice'. The carbon source and sink data for New Zealand, collated by GNS Science, NIWA, and Landcare Research, are reaching the level of maturity needed for inclusion in New Zealand's emission reporting. MfE has committed to incorporating them in their future emission reports. Southern Ocean carbon sink information will also be incorporated in the New Zealand Earth System Model being created by the Deep South National Science Challenge.

SCIENCE FOR A SAFER NEW ZEALAND

IMPACTS AND MEASURES AS ENVISIONED IN OUR 2017 STATEMENT OF CORPORATE INTENT

CORE SCIENCE AREA	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	Understanding Hazards **SCI Impact 10**	Enhanced global research presence By 2018, a global volcanic impacts database hosted by GNS Science is being operated, in collaboration with the US Geological Survey and the Global Volcanic Model.	The global volcanic impacts database has made substantial progress over the past two years. The database architecture has been refined by GNS Science with Sarah Brown and Susanna Jenkins of Global Volcano Model, Kristi Wallace of US Geological Survey, and Thomas Wilson of the University of Canterbury. Plans for GNS Science hosting of the database were worked into the proposal in March 2018 to be resourced via the NZVolcDB, as part of the Nationally Significant Databases & Collections SSIF contract for 2018-19. The database has grown significantly from data collected in 2016 from the Chaiten, Cordon Caulle, and Calbuco eruption impacts in Chile and Argentina. The newly-designed architecture has been piloted, with data collected live for the first time using the app Fulcrum, and stored in a fully relational database. Additional data were collected in March 2018 from the Ambae thick-ash impacts in Vanuatu, and from May 2018 from the eruption of Kilauea in Hawai'i. The public face of this data collection was released in 2016 and was designed and delivered by GNS Science, the University of Canterbury, and the US Geological Survey. See: https://volcanoes.usgs.gov/volcanic_ash/
Relates mainly to SCP Outcome 2: Increase New Zealand's resilience to natural hazards and reduce risk from earthquakes, volcanoes, landslides and tsunamis	Understanding Hazards **SCI Impact 15**	Better Mitigation Planning By 2018, an automated operational earthquake forecasting framework is in place.	This is not yet not in place. However, EQC has agreed to fund the programming effort to move the scientist-written code through to professionally written operational code. The programming effort, which began in May 2018, is expected to be completed by December 2018.
	Enhanced Recovery from Hazard Events **SCI Impact 16**	Better-informed policy development By 2018, there is significant uptake of the Measuring the Economics of Resilient Infrastructure Tool (MERIT) by key stakeholders.	The MERIT tool has had significant uptake by several stakeholders, significantly the Ministry of Transport and MBIE for an economic analysis of transport disruptions after the Kaikōura earthquake, and NZTA for assessing the impact of major network outages. It has also been used by the Wellington Lifelines Group (WeLG) and Greater Wellington Regional Council to support a business case to Treasury to build more resilience into Wellington's infrastructure. Riskscape and MERIT models were combined to produce a comprehensive picture of the damage and economic implications of a loss of infrastructure service following an earthquake. The modelling also demonstrated the reduction in economic impact after different mitigation options were introduced into the network. This helped WeLG to determine the best mix of options to proceed with. With WeLG comprising 15 lifeline organisations covering water, electricity, gas, and roads, this brings the number of organisations who have used MERIT to 20 over the past two years.

SCIENCE FOR A MORE PROSPEROUS NEW ZEALAND

IMPACTS AND MEASURES AS ENVISIONED IN OUR 2017 STATEMENT OF CORPORATE INTENT

CORE SCIENCE AREA	IMPACT AREA	IMPACTS AND MEASURES OF SUCCESS	PROGRESS/ACHIEVEMENT
Renewable Geothermal Energy 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	Enhanced Efficiency **SCI Impact 18**	By 2018, solutions for the control of corrosion, scaling, and reinjection are being employed by geothermal production companies to improve power station performance.	In the core-funded project 'Sustainability and the Environment – Reservoir & Plant Chemistry" we have undertaken experimental simulations and chemical modelling to devise ways to mitigate and manage the damaging effects of scaling and corrosion on geothermal power station infrastructure. The deposition of silica and stibnite (antimony sulfide) scales significantly reduces the efficiency of electricity generation and is very costly to remediate. We have shown that rapid cooling of geothermal water to low temperatures is highly effective in supressing scaling. This has prompted Contact Energy to undertake a large-scale trial of cold water injection, the first such trial undertaken in New Zealand. Heavy metal corrosion is a serious problem with low pH fluids, but the chemistry and mechanisms are poorly understood. A thermodynamic dataset compiled for corrosion modelling together with work by scaling specialist Quest Integrity can now be used commercially to address the problem for the geothermal industry. Deleterious precipitation of stibnite can occur in New Zealand geothermal binary power station circuits. A PhD chemistry research programme by Nellie Olsen, in collaboration with Victoria University of Wellington, identified the dissolved antimony sulfide species in solution and measured their thermodynamic properties. The aim of this research was to predict where and how these scale deposits occur inside power stations. This enables geothermal power companies to change their operating procedures.
Renewable Geothermal Energy 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	Enhanced Efficiency **SCI Impact 18**	Increased foreign earnings and greater socio-economic benefit By 2018, we are playing an increasingly leading role in international research, with greater involvement in the International Partnership for Geothermal Technology (IPGT) and the International Energy Agency-Geothermal Implementing Agreement (IEA-GIA).	GNS Science's involvement with the International Partnership for Geothermal Technology (IPGT) allows us to connect with global research and government organisations in Australia, USA, Switzerland, and Iceland. Collaboration between New Zealand geothermal researchers and their international counterparts supports the efficient development and operation of our own resources. There are currently seven GNS Science staff members associated with the steering committee and working groups of the IPGT, with Anya Seward holding the secretariat role. Our staff maintain a close relationship with MBIE's Kennie Tsui, who chairs IPGT, and the international members. Monthly teleconference meetings with country-by-country policy, technical, and scientific updates, supported by annual face-to-face meetings, are the key to keeping up-to-date with development and advances. Involvement in the IPGT has given rise to international collaborations in reservoir modelling, induced seismicity and, more recently, heat flow and rock properties. Issues and problems around geothermal development and research, both scientific and political, and the different ways to tackle them, are shared between the members of the IPGT providing an effective learning environment.

UNDERPINNING GEOSCIENCE KNOWLEDGE

IMPACTS AND MEASURES AS ENVISIONED IN OUR 2017 STATEMENT OF CORPORATE INTENT

CORE SCIENCE AREA	IMPACT AREA	IMPACTS AND MEASURES OF SUCCESS	PROGRESS/ACHIEVEMENT
Underpinning Geoscience Knowledge Relates to SCP Outcomes 1, 3, 4, 5.	Zealandia Revealed **SCI Impacts 28, 29**	Better asset management and sustainable resource decision-making By 2018, maps and associated datasets, as well as tectonic, paleogeographic and geodetic information, are being taken up regularly and used for marine and land-use planning and decision-making.	Spatial geoscience data, including geological maps, active fault locations and geodetic measurements are increasingly used by a wide range of sectors in New Zealand and overseas. Geological map information is used for urban planning, siting and maintenance of major infrastructure and development. It is also used for resource exploration and policy decisions for critical 'clean technology' minerals. We are integrating new airborne magnetic and other geophysical data into improved versions of these maps and are providing insight into subsurface geology to assist mineral exploration and locate potentially active faults. We are also incorporating this information into plate tectonic reconstructions to enable more effective petroleum exploration in under-explored offshore sedimentary basins. The location of active faults and their rupture characteristics, together with time-series geodetic data, are key components of the recently updated National Seismic Hazard Model that impacts on the New Zealand Building Code. We have used new datasets on major plate boundary faults, such as the Alpine Fault and Hikurangi Subduction zone, to create new earthquake response scenarios. They have also been used to better inform end-users including Eastcoast LAB. Other fault data has been used to inform seismic hazards assessment of critical facilities, such as the Manapouri, Matahina, and Clyde hydro dams, SH1 bridges, Martha Hill gold mine, and the reconstruction of SH1 at Kaikōura. Regional and local land-use planners have asked for improved active fault maps to assess fault rupture hazard for new residential development or for event response purposes. Land Information New Zealand has used geodetic measurements to reset the survey datum after the Earth's deformation caused by the Kaikōura earthquake, and tidal gauge data was used to assess level of tsunami inundation.
Underpinning Geoscience Knowledge Relates to SCP Outcomes 1, 3, 4, 5.	Zealandia Revealed **SCI Impacts 32, 33**	Geoscience information By 2018, all publicly-accessible databases and collections are maintained via a 'best practice' regime and regularly interrogated by research, government, and commercial sector end-users, with data and samples making a significant contribution to analysis, decision-making and risk reduction.	GNS Science has custodianship of eight high-value Nationally Significant Databases and Collections covering geological maps, rocks, fossils, groundwater, earthquakes, geomagnetism, and volcanism. In accordance with GNS Science's Data Management Strategy, these datasets have Data Management Plans and Risk Registers and are managed under a SSIF Infrastructure research programme that is undertaking improvements based on a Data Management Maturity Model. All are publicly accessible through a web presence via GNS Science, GeoNet or Intermagnet and have viewable and downloadable data. The datasets are regularly added to and enhanced through digitisation of legacy hard-copy records, quality assurance checking, underlying systems upgrade and delivery interface improvements. Statistics of dataset accession, dataset access, data downloads, product sales and citations are regularly collected and confirm increasing use and uptake of these data across a wide user base including universities and schools, local and central government, industry, consultants and the public. GNS Science is also custodian of many more high value, nationally important databases and collections. Those that are publicly accessible, such as the photographic image collections, active faults, landslides, tsunami gauges, geothermal, mineral and petroleum resources are widely used by diverse sectors. These datasets are managed with varying levels of SSIF Research Programme and other funding in accordance with GNS Science's Data Management Strategy. Notable recent examples of decision support and risk reduction enabled by these national datasets and collections include post-Kaikōura earthquake safety and response, Building Code revisions, water resource management, and policy setting around critical minerals and climate change.

PEOPLE / TOGETHER

GNS SCIENCE 2017 EXCELLENCE AWARD WINNERS

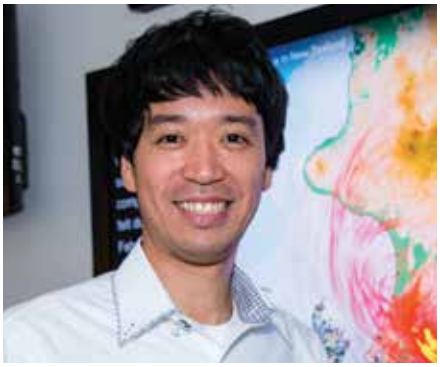
These awards are presented annually to celebrate staff for conspicuous achievement and for outstanding contributions to GNS Science. Staff are nominated by their peers and a group of senior staff select the category winners. There were 30 nominations across all five categories in late 2017.

ALBERT ZONDERVAN

Excellence in Commercial Services

'The wide variety of geoscience disciplines at GNS Science is special. That aspect motivates me to come to work every day. And just like in society, the science plans and applications always evolve. It feels good to be able to play my part in that with our Accelerator Mass Spectrometry facility.'

Albert plays a key role in the operation of the Rafter Radiocarbon Laboratory, which produces carbon-14 Accelerator Mass Spectrometry measurements with state-of-the-art precision for a wide range of applications. His expert knowledge, dedication, and extremely hard work has enabled the Rafter Lab to meet its exacting research and commercial goals.



YOSHI KANEKO

Excellence in Science

'At GNS Science I am surrounded by renowned scientists who provide valuable inputs to my research and openly share their ideas and discoveries. I am excited and happy to be part of an organisation that greatly contributes to our society.'

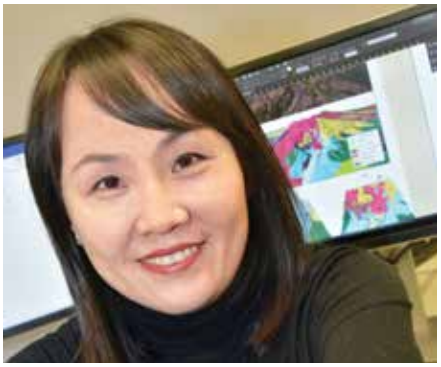
Yoshi's world-leading research on earthquake rupture nucleation and propagation has received international acclaim. This was underlined by his high-end research outputs on the 2016 Kaikōura earthquake which made huge contributions to the understanding of what occurred in this event. Yoshi collaborates widely and is an asset to New Zealand science.

SIMON COX

Excellence in Science Communication

'The application of our science, partnerships, and our business all stand to be developed through targeted outreach, so I focus a lot of effort on science communication. It's always an honour to stand in front of an audience representing GNS Science and outline the great work being done by our team.'

Simon makes an outstanding contribution in outreach and science communication. He has been highly successful in making an impact with schools, universities, iwi, regional and district councils, local communities, government agencies, professional groups, and the media. He works across a wide range of topics and sectors, but areas where he has been particularly effective are South Dunedin sea level rise and subsidence, earthquake and liquefaction hazards, Southern Alps landscape and geology, and Māori development.



KATY KELLY

Excellence in Outstanding Support

'I enjoy the friendly and collegial environment at GNS Science. Every week I am learning new things about the underpinning science while I'm designing infographics, and editing books and reports. The research we do is very important for the wellbeing of our community. I'm honoured to be part of it.'

Katy is blessed with loads of energy and initiative and she makes complex tasks look easy. Her input is invaluable in areas such as video production, book publishing, infographics and animation, and event and conference organising. Katy's flair and great attitude make her the go-to person for an ever expanding range of tasks.

NEVILLE PALMER

Excellence in Making a Difference

'From the mountain tops to the ocean bottom and everything between, I am privileged to be able to contribute to the valuable and diverse science that is carried out by the talented people around me at GNS Science. As a bonus, I get to experience our stunning country from north to south while I work.'

Neville is responsible for GNS Science being able to acquire world-class GPS data on how New Zealand is deforming due to tectonic forces. During the warmer months, he leads huge field programmes to obtain quality geodetic data while keeping on top of a myriad of details and maintaining goodwill with scores of landowners who make their properties available for this research. Neville's work underpins a large range of research not only within GNS Science, but also in the international Earth science community.

BEING A GOOD EMPLOYER

Our organisational culture and capabilities underpin our ability to deliver on our strategic direction. This requires a workforce that is smart, strategic and responsive.

The alignment between our key people policies and practices and the seven elements of being a good employer is outlined below:

ELEMENT	OUR ACTIVITIES THIS YEAR
Leadership, accountability and culture	• Embarked on a strategic review project to ensure we have the culture, structure, capability and capacity to lead globally influential science. • Hosted our third annual GNS Science Excellence Awards which celebrated excellence and high achievement across five categories, Science, Commercial Services, Science Communication, Outstanding Support, and Making a Difference.
Recruitment, selection and induction	• Recruited a diverse range of applicants both locally and internationally for 39 positions. • Renewed our Employer Accreditation with Immigration New Zealand. • Welcomed new staff with induction workshops.
Employee development, promotion and exit	• Used secondments for career development this year more so than previous years. • Facilitated our annual progression round. 23 staff members were successful in their application to move up our Science Career Path.
Flexibility and work design	• Received and approved eight requests for flexible working arrangements under Part 6AA of the Employment Relations Act. • 8% of our staff work part-time hours.
Remuneration, recognition and conditions	• A Pay and Employment Equity Review project was completed in partnership with the PSA with a number of recommendations that are currently being addressed.
Harassment and bullying prevention	• Reviewed and updated our Preventing Bullying, Harassment and Other Undesirable Behaviours policy to strengthen procedures and support for staff.
Safe and healthy environment	• The Executive led a number of wellbeing programmes during the year including 'kickstart bootcamp fitness', SunSmart awareness, Pink Shirt Day, and Step Challenge team-based walking. • Implemented health and safety software system providing improved ability to report incidents and hazards, and a more effective system for staff to check in and out when in the field.

BUILDING CORPORATE SERVICES TO SUPPORT SCIENCE

In April 2018, following a review of our executive and corporate functions, a final decision was made on changes to these structures. We increased the establishment number by 11.2 FTE positions. This review and its implementation was the first part of GNS Science positioning itself to more effectively achieve its vision. In doing this, we recognised the influence of the executive structure in shaping our leadership and the whole organisation. We also needed the right capability and capacity to lead and support our science work.

The former Executive Leadership Team of six (excluding the Chief Executive) was disestablished and replaced by five General Manager positions – Strategy, Science, Stakeholder Relations, Business Services, and People and Culture. We also established a fixed-term Principal Māori Relationships Advisor to the Chief Executive for a period of two years. All General Managers have shared responsibilities for the organisational strategy, the operational performance, and managing stakeholders.

The corporate structure – with functions grouped together in one department – has changed to a more centralised model for delivering corporate services. These changes are intended to strengthen support for the science programmes, ensure systems and processes can deliver on objectives, and realise new opportunities. Although the new structures took effect on 1 August 2018, GNS Science is still evolving and adjusting to a new way of working.

EQUAL EMPLOYMENT OPPORTUNITIES STATEMENT

We are committed to being an equal employment opportunity (EEO) employer through our organisation-wide EEO good employer practices relating to recruitment and selection, development, promotion/career progression, management and retention of staff. We strive to provide a safe working environment, ensuring staff are well inducted to their roles and provided with the required on-the-job training with a particular emphasis on safety.

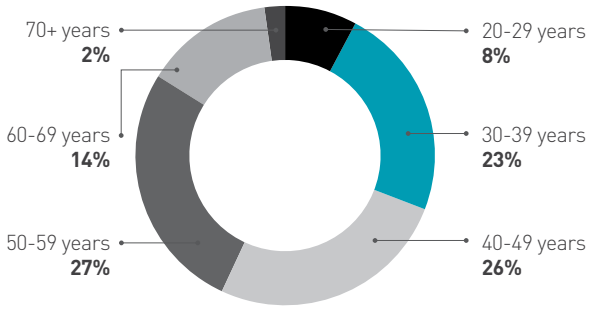
With up to 30% of our staff coming from countries other than New Zealand, we value the diversity this brings to our work and our daily interactions. We have identified the need for greater engagement with Māori both internally and externally. We have therefore proceeded with the appointment of a Principal Māori Relationships Advisor, reporting directly to the Chief Executive. This role will work internally and externally to grow our capability in relation to the needs of Māori.

DISABILITY (SELF-IDENTIFIED)

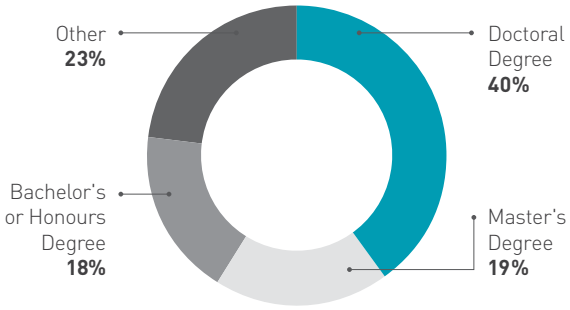
0.01% of GNS Science employees have declared having a disability within the past year.

WORKING TOGETHER

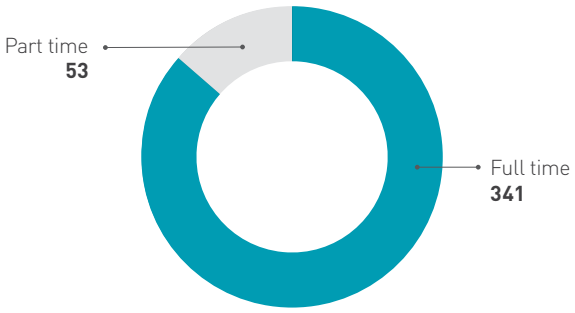
AGE



HIGHEST QUALIFICATION

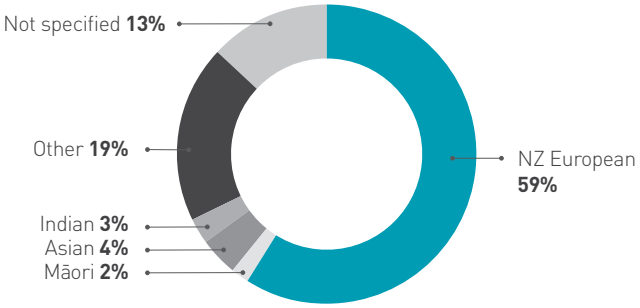


EMPLOYMENT STATUS

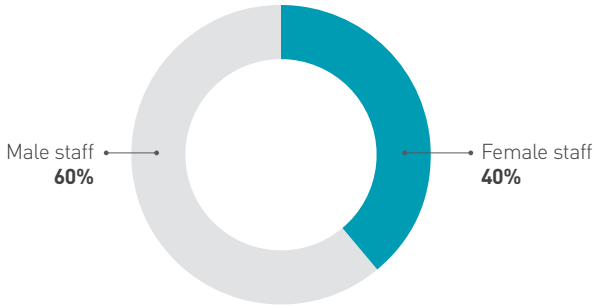


ETHNICITY PROFILE

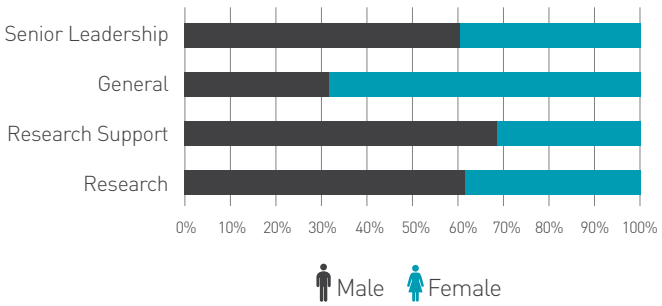
(self-identified)



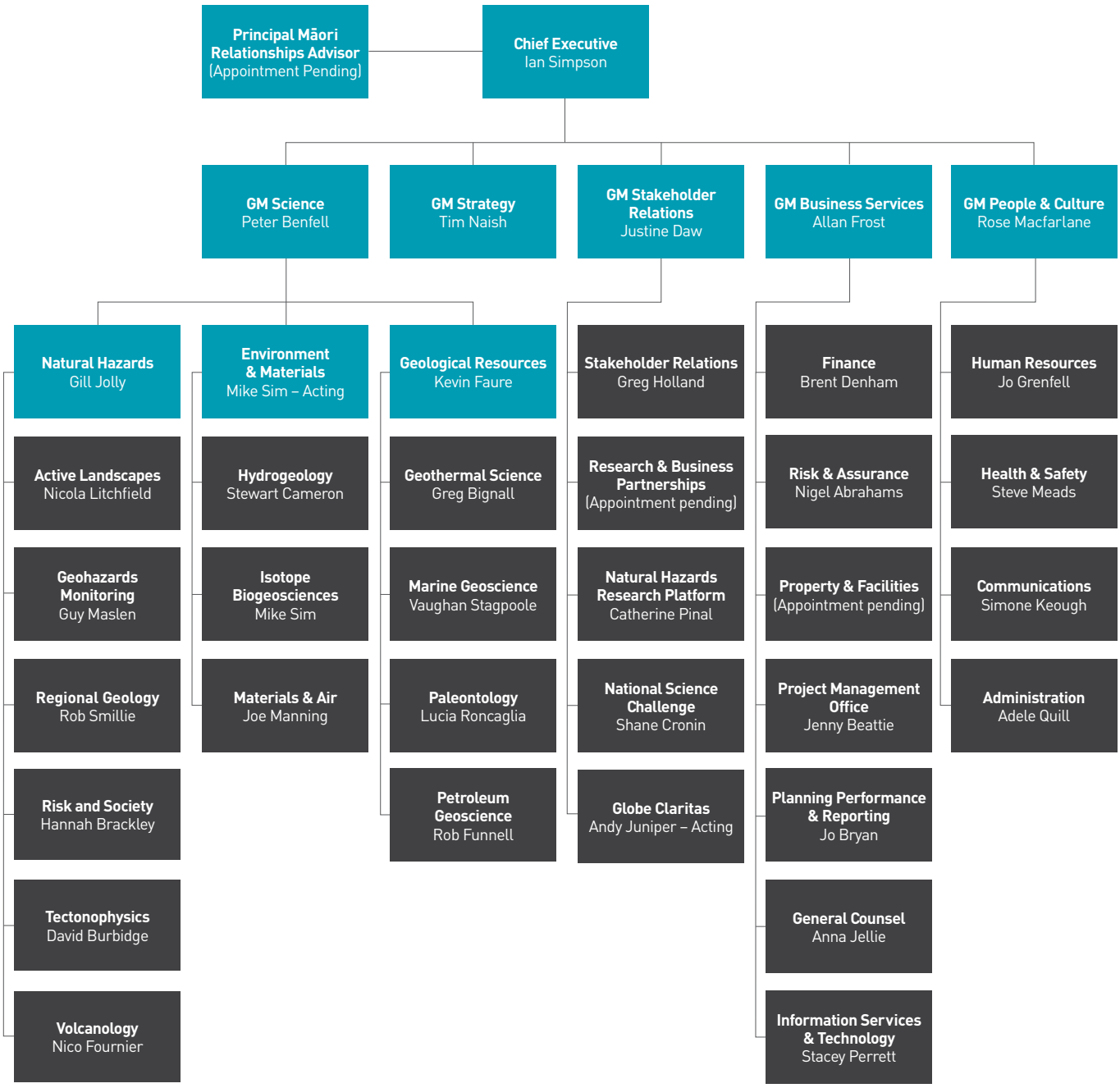
GENDER PROFILE



GENDER ROLES



ORGANISATIONAL STRUCTURE (AS AT OCTOBER 2018)



STRONG GOVERNANCE

BOARD OF DIRECTORS: Our experienced Directors are committed to enhancing the organisation and its reputation. Their diverse backgrounds ensure that there is sound oversight of all aspects of our operation.

DR NICOLA CRAUFORD

Chairman,

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

Wellington

(Appointed 1 July 2015)

Nicki is a professional company director with extensive governance and senior management experience including executive roles in the oil and gas and electricity sectors in New Zealand and the United Kingdom. She is currently Deputy Chair of Fire and Emergency New Zealand and a director of Watercare Services, Wellington Water, Orion New Zealand and the Environmental Protection Authority.

SARAH HAYDON

Deputy Chairman,

BSc, FCA, CMInstD

Auckland

(Appointed 1 July 2014)

Sarah is a director of Ports of Auckland Limited, The Co-operative Bank Limited and Cavalier Corporation 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, MInstD

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.

PROFESSOR STEVE WEAVER

BSc Hons, PhD, DSc, FGS, FNZIC, FRSNZ

Christchurch

(Appointed 1 July 2010)

Steve was formerly Deputy Vice-Chancellor (Research) and Head of the Department of Geological Sciences at the University of Canterbury. He has also held academic appointments at Birmingham, London and Nairobi Universities. He is a Fellow of the Royal Society of New Zealand and a board member of Research & Education Network New Zealand (REANNZ) Limited and a member of the Governance Group of the Resilience National Science Challenge. Steve has published extensively on the geology of New Zealand, Antarctica and East Africa, specialising in igneous petrology, volcanology, isotope geochemistry, tectonics and environmental science.

CHRIS BUSH

BE (Chem)(Hons), CMInstD

New Plymouth

(Appointed 1 January 2016)

Chris is an experienced oil and gas professional with 30-plus years spent 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.

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

PAUL WHITE

B Arch, MBS

Rawene, Hokianga

(Appointed 14 August 2017)

Paul is from the Ngāi Tūpoto hapū of Te Rarawa iwi and has had a 30-year background in Māori development and wide experience in the public service. He is currently a management and development consultant and professional director and lives in Rawene in the Hokianga. Over the past 15 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 the lines company Top Energy Ltd, Ngawha Geothermal Ltd, and Te Rarawa Iwi's asset holding company, Te Waka Pūpuri Pūtea. 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 and was a member of the bank's executive leadership team for 10 years, providing strategic counsel on people and culture. She has held leadership roles across the bank, including in its highly successful 2012 merger of its National Bank and ANZ Bank brands and its technology systems. She is a graduate of the Australian Institute of Company Directors, a 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.

EXPERIENCED LEADERSHIP

CURRENT EXECUTIVE TEAM: GNS Science's leadership team brings a wide range of skills to the management table. They are committed to maintaining the highest standards of professionalism to enable us to meet our business and science objectives.

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. He completed an MBA at INSEAD in France between his positions at Diageo.

TIM NAISH

General Manager, Strategy

PhD, University of Waikato

Tim joined GNS Science in August 2018 and his role is to improve the scale and impact of the research we undertake and to strengthen our strategic relationships nationally and internationally. He also drives the future strategic direction of the organisation. In his previous role as Director of the Antarctic Research Institute at Victoria University of Wellington, Tim led a team that built a world-renowned reputation in understanding how climate change is affecting Antarctica, and elaborating the policy implications of this. He was also Professor of Earth Sciences at Victoria University and has had a 20-year association with GNS Science. In his leadership roles he has built strong functional relationships with universities, Crown Research Institutes, funders and stakeholders.

JUSTINE DAW

General Manager, Stakeholder Relations

MA (1st Class Hons),
The University of Auckland

PGDip equivalent
Pushkin Institute, Moscow

MInstD (NZ)

Justine joined GNS Science in September 2018 after five and a half 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 government agencies, iwi, 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: Allan Frost, Justine Daw, Tim Naish, Ian Simpson, Peter Benfell, and Rose Macfarlane.

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

ALLAN FROST

General Manager, Business Services

Chartered Accountant; Fellow Certified Public Accountant

BBS, Massey University

Allan joined GNS Science as GM Business Services in July 2018. He heads the full suite of corporate functions including finance, legal, risk and assurance, ICT, property and facilities, project management, and performance reporting. He has over 20 years' experience in leading corporate teams in private and government sectors. His teams have won numerous awards for digitalisation of services, modernisation of major systems, and commercial, financial and legal advice. Prior to joining GNS Science, Allan ran his own consulting business, and he has held senior roles with the NZ Transport Agency and the Ministry of Agriculture and Forestry. Allan is of Tainui descent.

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. She oversees the full range of functions of these departments. 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 is experienced in managing change, understanding the challenges of differing business environments and dealing with a broad range of organisational culture and people matters.

OUTGOING EXECUTIVE TEAM

DISESTABLISHED ON 1 AUGUST 2018. As a result of the restructure of our Corporate Services Group in the first half of 2018, the former Executive Leadership Team (pictured) was disestablished and replaced by five General Manager positions – Strategy, Science, Stakeholder Relations, Business Services, and People and Culture (see previous spread). The outgoing team provided passionate leadership and rich knowledge for the organisation and we are indebted to their efforts.

DR GILL JOLLY

Director, Natural Hazards Division

MA, University of Cambridge, PhD, Lancaster University, FGS, CGeol

Gill has led the Natural Hazards Division since August 2014. It consists of 144 staff who undertake research and consultancy in earthquakes, volcanoes, landslides, tsunamis, geological mapping, engineering geology, earthquake engineering, risk modelling and social sciences. Gill is a volcanologist and joined GNS Science in 2006. Her background is in magma physics and lava flow dynamics, but she has had a diverse career including mineral exploration, environmental geochemistry and 3D geological modelling of ore deposits. She was formerly a director of the Montserrat Volcano Observatory in the West Indies.

DR CHRIS DAUGHNEY

Director, Environment and Materials Division

PhD, McGill University, Montreal, Canada

Since 2012, Chris has led the Environment and Materials Division, which includes research teams and commercial service units in hydrogeology, air quality, isotope biogeosciences and materials science. Chris joined GNS Science in 2002 and specialises in aqueous environmental geochemistry. His areas of interest include the chemical evolution of groundwater at the catchment scale, geomicrobiology and the use of tracer methods for evaluating in situ rates of water-rock interaction.

DR BRUCE GIRDWOOD

Interim General Manager, Stakeholder Relations

MSc, University of Cape Town

PhD, University of Wales, Swansea

Bruce joined GNS Science in August 2017 as leader of the Stakeholder Relations group. He has experience in industry focussed research and development and extensive management and commercial experience in private and state-owned sectors. He has 20 years' experience in the energy sector where he has held senior management roles in Transpower, Vector and the Electricity Commission, where he developed and implemented national energy efficiency programmes. Bruce has worked at the CSIR in South Africa, where his research focused on materials used in high temperature high stress environments.

DR KEVIN FAURE

Director, Geological Resources Division

PhD, University of Cape Town

Kevin leads the Petroleum, Geothermal, Paleontology and Marine Geoscience Departments. He specialises in stable isotope geochemistry and has researched and published on ore deposits, submarine volcanoes, gas hydrates and geothermal springs. He joined GNS Science in 1997 and has previously worked as an exploration and mining geologist in South Africa, and as a research scientist at the Geological Survey of Japan.

GRAHAM CLARKE

Director, Corporate Services/Chief Financial Officer

Chartered Accountant

Graham led the Corporate Services Division until January 2018. The Division provides the full range of functions to support the Company's internal operations including finance, information services, property, procurement, risk management and internal audit. A chartered accountant, Graham first joined the Company in 1994, having previously worked for KPMG in New Zealand and the UK.

DR ANNA JELLIE

Principal Advisor, Executive and Governance, Legal Counsel

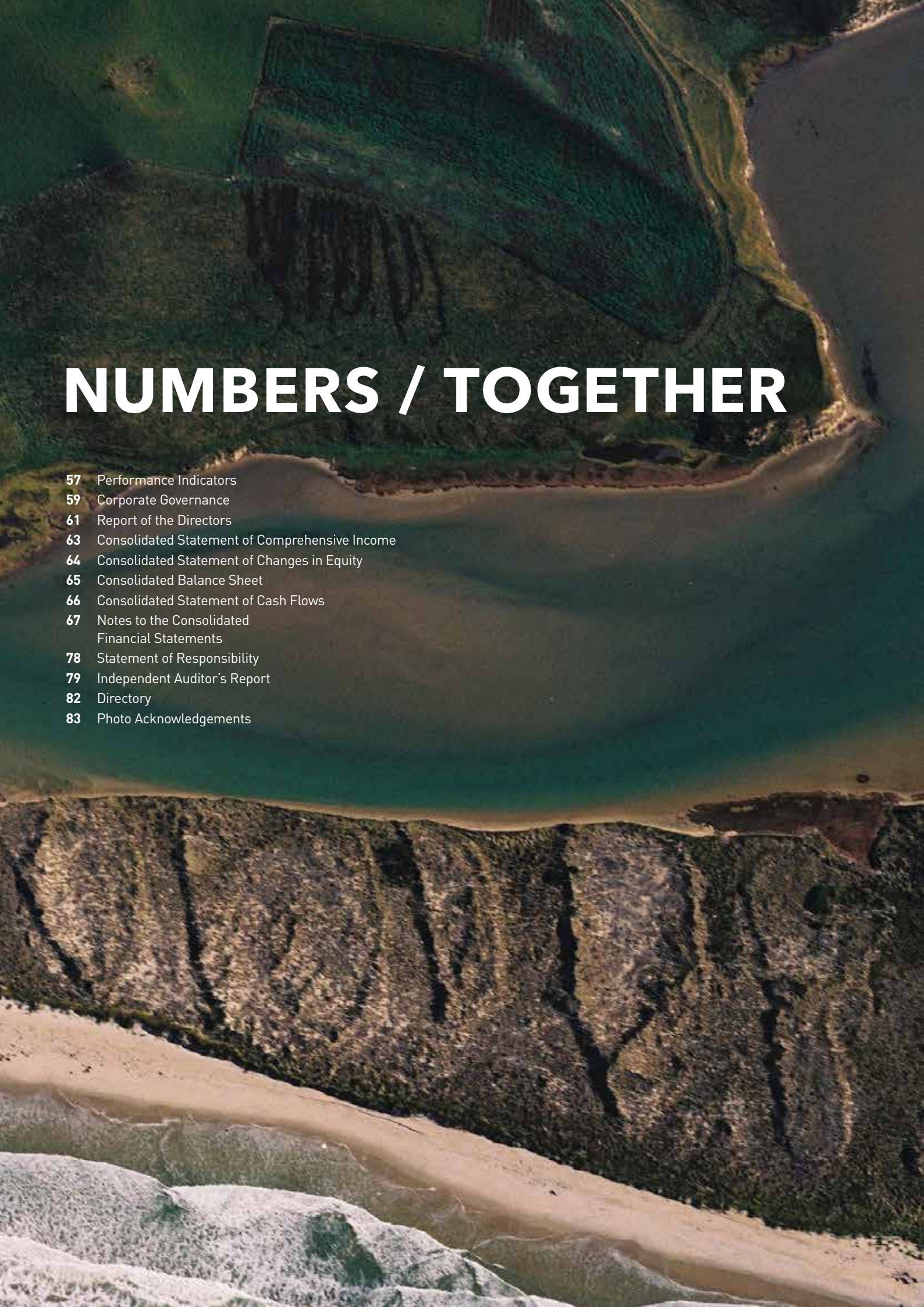
PhD and LLB, University of Otago

Anna provides legal and commercial advice to GNS Science. She joined us from Fonterra where she spent eight years as Corporate Counsel advising on legal issues across the business. Her key practice areas while at Fonterra were innovation and intellectual property. Prior to joining Fonterra, Anna worked in private legal practice at major New Zealand law firms, where she specialised in commercial and intellectual property law. She also graduated with a PhD in Biochemistry from the University of Otago.

KERYN BILDERBECK

General Manager, Human Resources

Keryn joined our Human Resources team in 2010 and was appointed to the position of General Manager, Human Resources in March 2015. She resigned in August 2018. She oversaw the full range of human resource functions and organisational health and safety across the Company.



NUMBERS / TOGETHER

PERFORMANCE INDICATORS

For the year ended 30 June 2018

Non-financial operating indicators
GNS Science's 2017 Addendum to the 2016-21 Statement of Corporate Intent (SCI) identified the following non-financial operating indicators against which progress to achieve the SCI operating outcomes are measured.

		Actual	Target
GNS Science Specific			
Organisational culture	Total recordable injury frequency rate, per 200,000 hours *	**3.1**	<1.3
	Staff proud to work for GNS Science (biennial climate survey) **	**	90%
CRI Generic			
End-user collaboration	Revenue per FTE from commercial sources ($000s)	**74**	82
Research collaboration	Papers with New Zealand co-authorship only	**17%**	15%
	Papers with international co-authorship only	**39%**	42%
	Papers with New Zealand and international co-authorship	**32%**	37%
	Papers co-authored	**71%**	93%
Technology transfer	Commercial reports per scientist FTE	**0.67**	1.0
Science quality	Impact of scientific publications (weighted citation index)	**3.48**	3.0
Financial indicator	Revenue per FTE ($000s)	**234**	227
Stakeholder engagement	Surveyed end-users who have confidence that GNS Science considers their sector's priorities when setting its research priorities	**68%**	>70%
	Surveyed end-users who have confidence that GNS Science has the ability to assemble "best" research teams	**72%**	>85%
	Surveyed end-users who have adopted knowledge from GNS Science in the past three years	**87%**	>90%

* Not achieved. In 2017/18 we introduced a comprehensive Health and Safety management system and look forward to improved outcomes in future years.

** Not completed due to the corporate and science review.

Financial performance indicators

	Actual 2018	Budget 2018	Actual 2017
Revenue ($000s)	**88,161**	89,814	86,348
Revenue growth[1]	**2%**	5%	5%
Operating results ($000s)			
Operating expenses[2]	**89,832**	85,762	81,627
EBITDA[3]	**5,295**	10,052	10,499
EBIT[4]	**(1,671)**	4,052	4,721
Profit before tax	**(1,032)**	4,322	5,147
Profit after tax	**(773)**	3,112	3,670
EBITDA per FTE	**14**	27	28
Total assets	**61,272**	60,064	63,798
Total equity	**34,109**	37,158	34,911
Capital expenditure[5]	**4,009**	7,000	3,933
Liquidity			
Quick ratio	**2.11**	1.97	2.47
Profitability[6]			
Return on equity	**(2.3%)**	8.7%	11.1%
Operating margin	**6.0%**	11.2%	12.2%
Return on capital employed	**(4.6%)**	8.7%	12.7%
Operational risk			
Profit volatility[7]	**22.4%**	15.8%	18.5%
Forecasting risk[8]	**(2.5%)**	(0.7%)	(1.2%)
Growth/Investment			
Capital renewal	**72%**	117%	68%
Dividend ($000)	**-**	250	250
Financial strength			
Equity ratio	**56%**	62%	55%
Cash and short-term investments	**21,855**	12,844	20,555

1. Revenue growth % – the lower than targeted growth is primarily due to the decline in commercial revenue levels against plan.
2. Operating expenditure – the increase in operating expenditure against plan and prior year is caused by the following major factors:
   - Impairment of an investment
   - Impairment of other assets (patents and intangibles)
   - Increased direct cost relating to Endeavour contract success
   - Increased employee benefit costs (including termination payments)
   - The use of contractors across key internal roles including project management, finance, IT, communications, legal, HR, change management.
3. EBITDA – reduced EBITDA is a function of lower revenue growth and increased costs.
4. EBIT and NPAT – reduced EBIT and NPAT is a function of a lower EBITDA.
5. Capital expenditure – at similar levels to the previous year but well-down on the capital investment plan. The strategic and corporate review had an impact on the completion of capital projects.
6. ROE/Operating margin and ROCE – the Loss after Tax totalling $773,000 has negatively impacted all of these ratios.
7. Profit volatility – this is the standard deviation of EBITDA/Average EBITDA for the previous 5 years. The increase on budget and prior year are caused by the viability of EBITDA to average EBITDA.
8. Forecasting risk – this is a measure of the five-year average of actual ROE less forecast ROE and is greater than budgeted due to the impact of the current year loss.

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 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 GNS Science 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 GNS Science 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. Our Board consists of six Directors and considers that it has an appropriate mix of skills, experience and independence to ensure that the Company is governed appropriately.

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 on-line 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 2018 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 and one advisory panel operating during the year - the Audit and Risk Committee, the Remuneration Committee, the Health, Safety and Environment Committee, the Science Committee and the Strategic Science and User Advisory Panel. 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 Meetings		Audit and Risk Committee		Remuneration 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	11	4	4	4	4	3	3	2	2
Sarah Haydon	11	11	4	4	4	4	-	-	-	-
Chris Bush	11	11	4	3	-	-	3	3	-	-
John Sharpe	11	11	4	4	-	-	-	-	2	2
Steve Weaver	11	10	-	-	4	4	-	-	2	2
Paul White	10	8	-	-	-	-	3	3	-	-

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

The Board evaluates its own performance and provides the results of the evaluation to the Responsible Minister's representative on an annual basis.

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.

REMUNERATION COMMITTEE

The Remuneration 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

The Health, Safety and Environment 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, assesses performance against those targets, assures that the Company has adequate resources to operate the business safely and reviews serious incidents and audit results, evaluating responses and being satisfied with 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. One meeting was held during the year in conjunction with a meeting of the Strategic Science and User Advisory Panel and the Science Division Directors. 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.

STRATEGIC SCIENCE AND USER ADVISORY PANEL (SSUAP)

The SSUAP is a standing advisory panel to the Board, providing high level strategic advice on research strategies and scientific programmes, and on new technology and knowledge, user relevance and technology transfer. This advice includes matters concerning effective performance and risk management, international perspectives, technology and knowledge transfer and update, interpretation of developments in science and its application, and enhanced collaboration with other entities in New Zealand and worldwide.

The members of the SSUAP are Mr David Middleton (Chair), Dr Chris Pigram, Dr Anna de Raadt, Dr Mike Allen, Dr Mac Beggs, Dr Charlotte Severne, Professor Brent McInnes, and Professor Lionel Carter.

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, 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 and Risk Committee meets quarterly with the Internal Auditor without management present.

GNS Science has an established framework for managing risk to inform strategic and business planning processes, optimise allocation of resources and 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 AUDITOR

GNS Science is committed to ensuring that the external audit provider is able to carry out its functions independently. Our External Audit 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, such that the audit opinion is highly reliable and credible. The Office of the Auditor-General has appointed Deloitte to perform the statutory audit during the year ended 30 June 2018. Deloitte personnel attended three 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 2018.

CONFLICTS OF INTEREST

All Directors and members of the Executive Leadership Team are required to disclose any conflicts of interest or if they have an interest in any transaction, in which case they will generally not be entitled to partake in the discussion or 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. No Directors provided professional services to the Company during the year.

REPORT OF THE DIRECTORS

For the year ended 30 June 2018

The Directors are pleased to present the audited financial statements of GNS Science for the year ended 30 June 2018. The financial statements have been prepared in accordance with generally accepted accounting practice in New Zealand and the Financial Reporting Act 1993.

The Controller and 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 29 of the Public Finance Act 1977, has appointed Deloitte 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

Paul White was appointed to the Board on 14 August 2017 and Felicity Evans from 1 July 2018.

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	2018 $	2017 $
Nicola Crauford	1 July 2015	47,356	46,678
Sarah Haydon	1 July 2014	29,598	29,174
Chris Bush	1 January 2016	23,678	23,339
John Sharpe	1 September 2016	23,678	19,505
Steve Weaver	1 July 2010	23,678	23,339
Paul White	14 August 2017	20,718	-

During the year, no Director has received or became entitled to receive any benefit other than as disclosed above.

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	2018	2017
100-110	31	23
110-120	28	28
120-130	19	23
130-140	18	12
140-150	14	11
150-160	9	9
160-170	9	9
170-180	6	5
180-190	3	3
190-200	1	2
220-230	-	1
230-240	1	3
240-250	4	1
250-260	1	1
320-330	1	1
350-360	-	1
470-480	1	-

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 2018.

DIVIDENDS

No dividend was declared during the year to 30 June 2018 (2017: $250 000).

DIRECTORS' INDEMNITY AND INTEREST

The Company has insurance cover for Directors in respect of any act or omission in their capacity as a Director of the Company. Directors have signed a Deed of Indemnity on 29 November 2017, whereby the Company indemnifies the 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, liability for breach of duty under section 131 of the Companies Act 1993 or a breach of fiduciary duty owed to the Company.

Directors' interests disclosed at 30 June 2018 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
	Director	Environmental Protection Authority *
	Director	Orion New Zealand Ltd
	Director	Watercare Services Ltd
	Specialist Advisor	Worley Parsons New Zealand Ltd
	Director and shareholder	Riposte Consulting Ltd
	Deputy Chair	Fire and Emergency New Zealand
	Member	Electoral Authority, Cooperative Bank Limited
Sarah Haydon	Director	Cavalier Corporation Limited
	Chair	New Zealand Riding for the Disabled Association Inc
	Associate	The Boardroom Practice Limited
	Trustee	R&E Seelye Trust
	Director/Deputy Chairman	The Cooperative Bank Limited
	Director	Cooperative Life Limited
	Director	Ports of Auckland Limited
Prof. Steve Weaver	Member	Royal Society of New Zealand
	Director, Chair HR Committee	Research & Education Advanced Network NZ (REANNZ)
	Governance Group	Resilience National Science Challenge
	Advisor	GAMA Foundation
Chris Bush	Director and Shareholder	SRM Solutions Limited
	Shareholder	QSP Limited
John Sharpe	Director and Shareholder	Photara Technologies Limited
	Director	Sexing Technologies New Zealand Limited
	Director and Shareholder	Weka Labs Limited
	Director	Accelerenz Limited
Paul White	Member	Te Rarawa Iwi
	Chairman	Te Rarawa Farming Ltd
	Director	Te Rarawa To Tātou Kainga Ltd
	Director	Top Energy Ltd
	Council Member	Kaunihera Māori, Heritage NZ Pouhere Taonga
	Member	Māori Health Committee, HRC
	Director/Shareholder	Torea Tai Consultants Limited
	Executive Member	Matapihi (Māori Housing Body)

* Nicola Crauford is also a member of the Environmental Protection Authority Decision-Making Committee to hear an application from OMV New Zealand for a marine discharge consent.

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
29 August 2018

FINANCIAL STATEMENTS

Consolidated Statement of Comprehensive Income

For the year ended 30 June 2018

in thousands of New Zealand dollars	Note	**Actual 2018**	Budget 2018	Actual 2017
Revenue				
Research contracts		**60,429**	57,232	54,226
Commercial		**15,745**	20,283	20,169
GeoNet services		**11,978**	12,267	11,901
Other income		**9**	32	52
Total revenue	2	**88,161**	89,814	86,348
Operating Expenses				
Employee benefit expense	3	**41,302**	42,115	38,933
Other operating expenses	3	**37,800**	33,367	32,023
GeoNet direct expenses		**3,764**	4,280	4,893
		82,866	79,762	75,849
Profit before interest, tax, depreciation and amortisation		**5,295**	10,052	10,499
Depreciation	6	**4,647**	4,800	4,590
Amortisation and impairment	7	**2,319**	1,200	1,188
(Loss)/profit before interest and tax		**(1,671)**	4,052	4,721
Interest income		**672**	270	426
Interest expense		**(33)**	-	-
(Loss)/profit before tax		**(1,032)**	4,322	5,147
Income tax	4	**259**	(1,210)	(1,477)
(Loss)/profit after tax		**(773)**	3,112	3,670
Other comprehensive income		**(29)**	-	29
Total comprehensive income attributable to owners		**(802)**	3,112	3,699

The accompanying notes form part of these financial statements.

Consolidated Statement of Changes in Equity

For the year ended 30 June 2018

in thousands of New Zealand dollars	Note	Share capital	Equity reserves		Total equity
			Retained earnings	Cash flow hedge reserve	
Balance at 1 July 2016		6,167	25,295	-	31,462
Profit after tax		-	3,670	-	3,670
Other comprehensive income		-	-	29	29
Dividend	5	-	(250)	-	(250)
Balance at 30 June 2017		6,167	28,715	29	34,911
Loss after tax		-	(773)	-	(773)
Other comprehensive income		-	-	(29)	(29)
Dividend	5	-	-	-	-
Balance at 30 June 2018		**6,167**	**27,942**	**-**	**34,109**

The accompanying notes form part of these financial statements.

Consolidated Balance Sheet

As at 30 June 2018

in thousands of New Zealand dollars	Note	**Actual 2018**	Budget 2018	Actual 2017
Equity				
Share capital	5	**6,167**	6,167	6,167
Equity reserves		**27,942**	30,991	28,744
Total equity		**34,109**	37,158	34,911
Represented by:				
Non-current assets				
Property, plant and equipment	6	**27,505**	32,700	28,812
Intangible assets	7	**1,195**	2,850	3,400
Investments		**30**	30	30
Total non-current assets		**28,730**	35,580	32,242
Current assets				
Cash and cash equivalents	12	**2,292**	12,844	2,555
Short term investments	12	**19,000**	-	18,000
Trade receivables	8	**6,872**	6,390	6,497
Prepayments		**1,838**	1,800	1,452
Current tax		**292**	-	-
Deferred tax	9	**239**	-	-
Work in progress		**2,009**	3,450	3,052
Total current assets		**32,542**	24,484	31,556
Total assets		**61,272**	60,064	63,798
Non-current liabilities				
Deferred tax	9	**-**	901	457
Non-current provisions	10	**1,897**	1,815	1,857
Total non-current liabilities		**1,897**	2,716	2,314
Current liabilities				
Trade and other payables	11	**10,571**	7,556	7,742
Current provisions	10	**3,011**	2,884	3,026
Revenue in advance		**11,684**	9,500	15,050
Provision for income tax		**-**	-	755
Provision for dividend	5	**-**	250	-
Total current liabilities		**25,266**	20,190	26,573
Total liabilities		**27,163**	22,906	28,887
Net assets		**34,109**	37,158	34,911

The accompanying notes form part of these financial statements.

For and on behalf of the Board:

Dr Nicola Crauford
Chairman
29 August 2018

Sarah Haydon
Deputy Chairman
29 August 2018

Consolidated Statement of Cash Flows

For the year ended 30 June 2018

in thousands of New Zealand dollars	Note	**Actual 2018**	Budget 2018	Actual 2017
Cash flows from operating activities				
Cash was provided from:				
Receipts from customers		**85,540**	85,174	90,230
Interest received		**597**	270	328
		86,137	85,444	90,558
Cash was applied to:				
Payments to suppliers and employees		**(79,874)**	(79,387)	(74,548)
Interest paid		**(33)**	-	-
Income tax paid		**(1,484)**	(1,210)	(1,136)
		(81,391)	(80,597)	(75,684)
Net cash flows from operating activities	12	**4,746**	4,847	14,874
Cash flows from investing activities				
Cash was provided from:				
Sale of property, plant and equipment		**-**	-	65
Maturity of short term investments		**33,000**	-	7,000
		33,000	-	7,065
Cash was applied to:				
Purchase of property, plant, equipment and intangible assets		**(4,009)**	(7,000)	(3,933)
Placement of short term investments		**(34,000)**	-	(25,000)
		(38,009)	(7,000)	(28,933)
Net cash flows from investing activities		**(5,009)**	(7,000)	(21,868)
Cash flows from financing activities				
Cash was applied to:				
Dividends paid		**-**	(250)	(500)
		-	(250)	(500)
Net cash flows from financing activities		**-**	(250)	(500)
Net increase in cash and cash equivalents		**(263)**	(2,403)	(7,494)
Effects of exchange rate changes on the balance of cash held in foreign currencies		**-**	-	2
Opening cash and cash equivalents		**2,555**	15,247	10,047
Closing cash and cash equivalents		**2,292**	12,844	2,555

The accompanying notes form part of these financial statements.

NOTES TO THE CONSOLIDATED FINANCIAL STATEMENTS

for the year ended 30 June 2018

1. REPORTING ENTITY AND ACTIVITIES

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

The subsidiaries of the Company 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 venture formed to undertake a contract for dam hazard management in Vietnam.

2. REVENUE

Strategic funding

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

Revenue from other research and commercial contracts

Revenue earned from the supply of goods and services is measured at the fair value of consideration received. Revenue from services is recognised based on the percentage of work completed. Any amounts received in relation to work not yet commenced are recorded as revenue in advance.

Revenue from the supply of goods is recognised when the significant risks and rewards of ownership of the goods have been transferred to the buyer.

Revenue for the year was derived as follows:

in thousands of New Zealand dollars	**2018**	2017
Strategic Science Investment Fund contracts	**32,007**	27,980
Contestable funding contracts	**24,432**	21,637
Marsden funding contracts	**1,155**	1,726
Research subcontracts	**2,835**	2,883
Research contracts	**60,429**	54,226
Commercial – New Zealand	**11,249**	12,037
Commercial – overseas	**4,496**	8,132
Commercial revenue	**15,745**	20,169
GeoNet services	**11,978**	11,901
Other income	**9**	52
Total revenue	**88,161**	86,348

3. EMPLOYEE BENEFIT EXPENSE AND OPERATING EXPENSES

Employee benefit expense includes an amount of $648,000 (2017: $nil) relating to termination benefits paid or payable at 30 June 2018 and have been recognised as the Company can no longer withdraw the offer of those benefits.

Operating expenses are made up as follows:

in thousands of New Zealand dollars	**2018**	2017
Conferences and training	**812**	856
Research contracts	**15,668**	13,098
Materials and supplies	**2,361**	2,256
Services and contracts	**12,277**	9,989
Travel and vehicle	**3,000**	2,963
Rent	**247**	256
Site and communication	**2,216**	2,102
Auditor's remuneration – audit services	**78**	79
Directors' fees	**169**	165
Bad and doubtful debts	**84**	25
Foreign exchange gain	**(34)**	(20)
Loss/(gain) on disposal of property plant and equipment	**506**	(18)
Other	**416**	273
Total Operating expenses	**37,800**	32,023

4. INCOME TAX

The income tax expense is determined as follows:

in thousands of New Zealand dollars	**2018**	2017
Reconciliation of income tax expense		
(Loss)/profit before tax	**(1,032)**	5,147
Tax at rate of 28%	**(289)**	1,441
Non deductible items in determining assessable income	**30**	36
Total tax (credit)/expense	**(259)**	1,477
The taxation charge is represented by		
Current tax	**437**	1,740
Deferred tax	**(696)**	(263)
Total tax (credit)/expense	**(259)**	1,477

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

5. SHARE CAPITAL

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.

On 30 June 2017 a dividend of $250,000 was paid to holders of fully paid ordinary shares in respect of the 2017 financial year. No dividend has been declared for the year ended 30 June 2018.

in thousands of New Zealand dollars	**2018**	**2017**
Authorised and Issued Capital: 6,167,000 ordinary shares	**6,167**	6,167

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

in thousands of New Zealand dollars	Land	Buildings and improvements	Plant and machinery	Laboratory equipment	IT equipment	Furniture, fittings and office equipment	Vehicles	Total
Cost								
Balance at 1 July 2016	2,527	19,958	4,451	30,011	6,312	3,523	1,123	67,905
Additions	-	573	91	1,079	982	145	246	3,116
Disposals	-	(544)	(30)	(2,005)	(77)	(153)	(164)	(2,973)
Balance at 30 June 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**
Accumulated depreciation								
Balance at 1 July 2016	-	8,273	1,960	19,814	4,572	2,140	822	37,581
Disposals	-	(530)	(29)	(1,986)	(76)	(150)	(164)	(2,935)
Depreciation	-	1,254	345	1,772	800	302	117	4,590
Balance at 30 June 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**
Net book value at 30 June 2017	2,527	10,990	2,236	9,485	1,921	1,223	430	28,812
Net book value at 30 June 2018	**2,527**	**10,819**	**2,007**	**9,172**	**1,573**	**1,127**	**280**	**27,505**

Heritage assets – collections, library and databases

The Company owns various collections, library resources and databases that are an integral part of the research work undertaken by the Company. 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

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 method 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
Patents	4-20 years
Capitalised development costs	4-8 years

in thousands of New Zealand dollars	Software	Patents	Capitalised development costs	Total
Cost				
Balance at 1 July 2016	11,730	1,224	650	13,604
Additions	476	36	-	512
Disposals	(897)	(93)	-	(990)
Balance at 30 June 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**
Accumulated amortisation				
Balance at 1 July 2016	8,320	548	650	9,518
Disposals	(894)	(86)	-	(980)
Amortisation	1,110	78	-	1,188
Balance at 30 June 2017	8,536	540	650	9,726
Disposals	(82)	(339)	(136)	(557)
Amortisation	821	77	-	898
Impairment	1,421	-	-	1,421
Balance at 30 June 2018	**10,696**	**278**	**514**	**11,488**
Net book value at 30 June 2017	2,773	627	-	3,400
Net book value at 30 June 2018	**885**	**310**	**-**	**1,195**

A sector downturn, increasing competition and reduced sales of a software offering have led management to undertake an impairment review of certain capitalised software costs in May 2018. 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 at 30 April 2018.

8. TRADE RECEIVABLES

The carrying value of receivables approximates their fair value. As at 30 June 2018 all overdue receivables have been assessed for impairment and appropriate provisions applied.

in thousands of New Zealand dollars	**2018**	2017
Trade receivables	**6,986**	6,527
Allowance for doubtful debts	**(114)**	(30)
	6,872	6,497

Ageing profile of past due trade receivables at balance date

in thousands of New Zealand dollars	**2018**	2017
Past due 1-30 days	**675**	1,269
Past due 31-60 days	**187**	197
Past due over 61 days	**785**	235
	1,647	1,701

Movement in the provision for doubtful debts

in thousands of New Zealand dollars	**2018**	2017
Balance at 1 July	**30**	42
Accounts written off during the year	**-**	(38)
Increase in allowance recognised in profit or loss	**110**	26
Reversal of impairment losses on receivables	**(26)**	-
Balance at 30 June	**114**	30

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 for doubtful debts. Changes in the carrying amount of doubtful debts are recognised in profit or loss.

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

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 liabilities are recognised for all 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 taxable profits 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

in thousands of New Zealand dollars	**2018**	2017
Deferred tax liabilities/(assets) arise from the following:		
Property, plant and equipment	**1,059**	1,384
Intangible assets	**28**	384
Provisions	**(1,292)**	(1,300)
Doubtful debts	**(32)**	(8)
Capitalised relocation expenses	**(2)**	(3)
Deferred tax (asset)/liability recognised at 30 June	**(239)**	457

Movements in deferred tax

in thousands of New Zealand dollars	**2018**	2017
Balance at 1 July	**457**	720
Charged to income	**(679)**	(76)
Adjustments – prior year	**(17)**	(187)
	(696)	(263)
Balance at 30 June	**(239)**	457

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.

	Current		Non-current	
in thousands of New Zealand dollars	**2018**	2017	**2018**	2017
Annual leave	**2,566**	2,540	**786**	807
Long service leave	**319**	308	**970**	873
Retirement leave	**126**	178	**141**	177
	3,011	3,026	**1,897**	1,857

11. TRADE AND OTHER PAYABLES

in thousands of New Zealand dollars	**2018**	2017
Trade payables	**6,804**	4,402
Accrued expenses	**3,767**	3,340
	10,571	7,742

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

in thousands of New Zealand dollars	**2018**	2017
Profit/(Loss)	**(773)**	3,670
Add/(less) items classified as investing activities:		
Net loss/(gain) on disposal of property, plant and equipment	**506**	(18)
Adjust non-cash items:		
Depreciation	**4,647**	4,590
Amortisation and impairment	**2,319**	1,188
Bad and doubtful accounts	**84**	25
Net unrealised exchange (gain)/loss	**(113)**	3
(Decrease)/increase in provision for income tax	**(1,047)**	581
Decrease in deferred tax	**(696)**	(263)
Increase in non-current provisions	**40**	80
	5,234	6,204
Add/(less) movements in working capital items:		
Increase in accounts receivable and prepayments	**(761)**	(243)
(Decrease)/increase in payables, current provisions and revenue in advance	**(552)**	6,428
Change in receivables and payables relating to investing activities	**49**	305
Decrease/(increase) in work in progress	**1,043**	(1,472)
	(221)	5,018
Net cash flows from operating activities	**4,746**	14,874

13. RELATED-PARTY TRANSACTIONS

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

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

in thousands of New Zealand dollars	**2018**	2017
Short term benefits	**2,212**	1,858

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 profit 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 profit or loss 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 profit or loss.

At balance date the Group had no forward foreign exchange contracts in place (2017 – one contract with a New Zealand dollar fair value of $29,000).

The carrying amounts of the Group's foreign currency denominated assets and liabilities was as follows:

	Liabilities		**Assets**	
in thousands of New Zealand dollars	**2018**	2017	**2018**	2017
Australian Dollar	**(43)**	(44)	**110**	47
Canadian Dollar	**(2)**	(68)	**-**	-
Euro	**(122)**	(2)	**41**	24
GBP Sterling	**(64)**	(6)	**50**	-
Japanese Yen	**-**	-	**-**	2
Indonesian Rupiah	**-**	(11)	**-**	-
Danish Krone	**-**	(3)	**-**	-
Norwegian Krone	**(114)**	-	**-**	1
Omani Rial	**-**	-	**435**	1,022
US Dollar	**(181)**	(743)	**405**	1,055
	(526)	(877)	**1,041**	2,151

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 2018 were in the range of 2.20%-3.51% (2017: 2.57%-3.47%).

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

Market risk and sensitivity analysis
As at 30 June 2018, if the New Zealand dollar (NZD) had strengthened by 5% against foreign currencies, with all other variables held constant, the profit for the year would have decreased by $17,000 (2017: $61,000). A 5% weakening of the NZD would have increased reported profit by $18,000 (2017: $66,000).

If interest rates had been 50 basis points higher/lower and all other variables were held constant, reported profit for the year would increase/decrease by $110,000 (2017: $79,000).

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 risks
The Group manages liquidity risk by maintaining adequate reserves, cash deposits and short term investments, by monitoring forecast and actual cash flows and 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.

in thousands of New Zealand dollars	**2018**	2017
Within one year	**32**	103
Between one and five years	**18**	22
Over five years	**-**	2
	50	127

Capital commitments

in thousands of New Zealand dollars	**2018**	2017
Contracted and on order	**582**	817
Authorised but not yet contracted	**1,528**	1,555
	2,110	2,372

16. CONTINGENT LIABILITIES

The Group has no contingent liabilities (2017: $nil).

17. EVENTS AFTER THE BALANCE DATE

There were no significant events after the balance date (2017: 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.

Measurement basis
The financial statements of the Group have been prepared on an 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 Company 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 holds loans and receivables. These are measured at cost less impairment, or in the case of trade receivables, reduced by an allowance for doubtful debts.

Financial liabilities, excluding derivative financial instruments, are classified as 'other financial liabilities'.

Other financial liabilities are initially measured at fair value, net of transaction costs. Other financial liabilities are subsequently measured at amortised cost, with interest expense recognised on an effective interest basis.

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 and 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 2018.

The key items applicable to the Group are:

NZ IFRS 15: Revenue from contracts with customers (effective for annual periods beginning on or after 1 January 2018)

NZ IFRS 15 sets out a five-step model to apply when recognising revenue for contracts with customers. The Group has started an impact analysis but has yet to fully assess the impact of NZ IFRS 15. The Group will adopt NZ IFRS 15 for the first time for the year ending 30 June 2019 and there may be some changes to revenue recognition.

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.

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

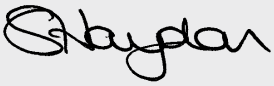
The Board is responsible for the preparation of the Group's annual financial statements and statement of performance and for the judgements made in them.

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
29 August 2018



Sarah Haydon
Deputy Chairman
29 August 2018

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 2018

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 63 to 77, that comprise the consolidated balance sheet as at 30 June 2018, 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 2018; 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 29 August 2018. 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.

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

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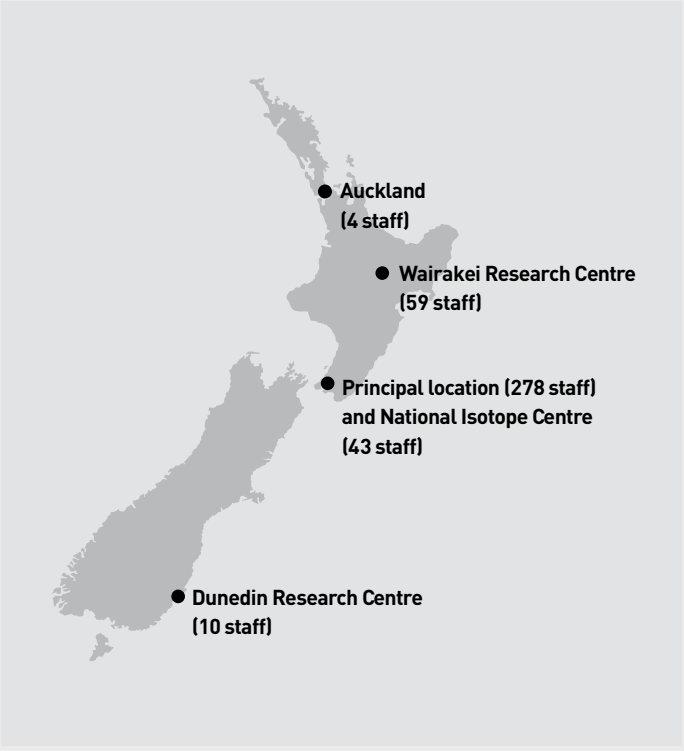

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www.gns.cri.nz
www.geonet.org.nz

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