

ANNUAL REPORT 2018



innovate | adapt | deliver

OUR PURPOSE

To deliver enhanced scientific and research services to the public health, food safety, security and justice systems and the environmental sector and to contribute to the economic, environmental and social wellbeing of people and communities.

OUR MISSION

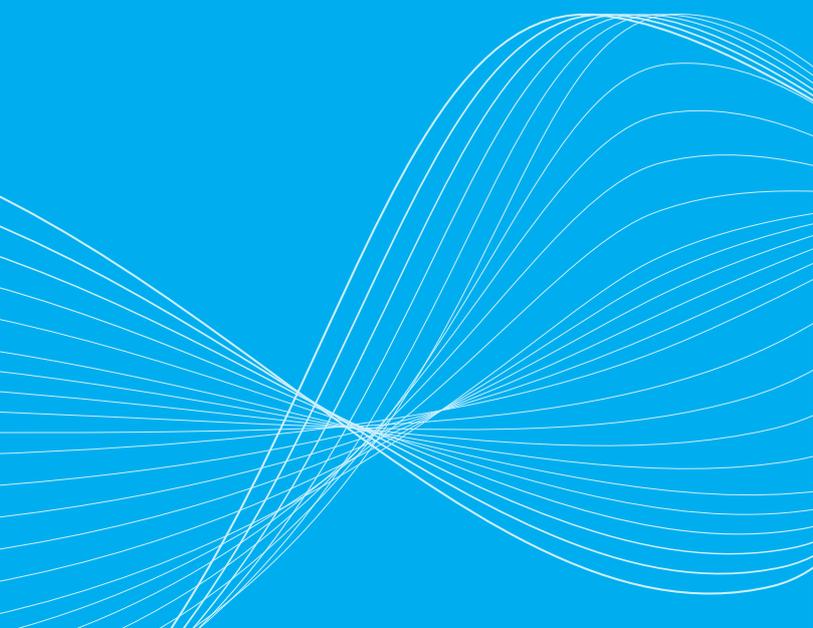
Keeping people and communities safe, healthy and prosperous through smart and sustainable science.

OUR VISION

ESR is a world leader in the science that keeps people safe, healthy and prosperous. Our customers regard us as a critical partner for their work and we are known for our service ethic. They seek us out for our innovative and high-quality science solutions and leading-edge research. We are a magnet for talented people.

OUR VALUES

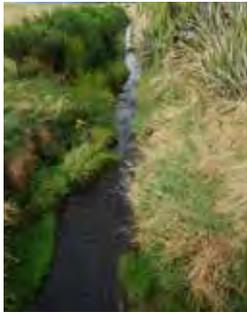
- Team spirit
- Quality counts
- Doing the right thing
- Pushing the boundaries

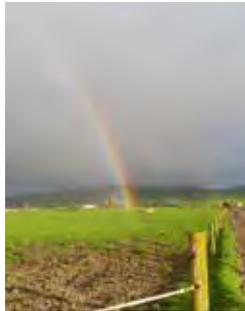
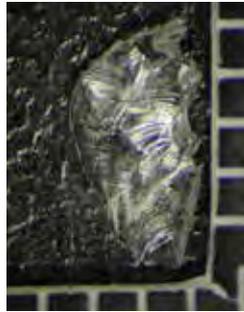




WE ARE ESR – THROUGH THE EYES OF OUR STAFF

A challenge was thrown down to our people last year: Send us photos of what you think ESR is. We received this amazing array of images from our staff.







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ABOUT US



*ESR is a New Zealand Crown
Research Institute that
specialises in science relating to
people and communities.*

ABOUT US

ESR is a New Zealand Crown Research Institute that specialises in science relating to people and communities.

Our science, technology and clinical services, and innovative products help safeguard people's health, protect food-based economies, improve the safety of our freshwater and groundwater, reduce land waste and help prevent and solve crime.

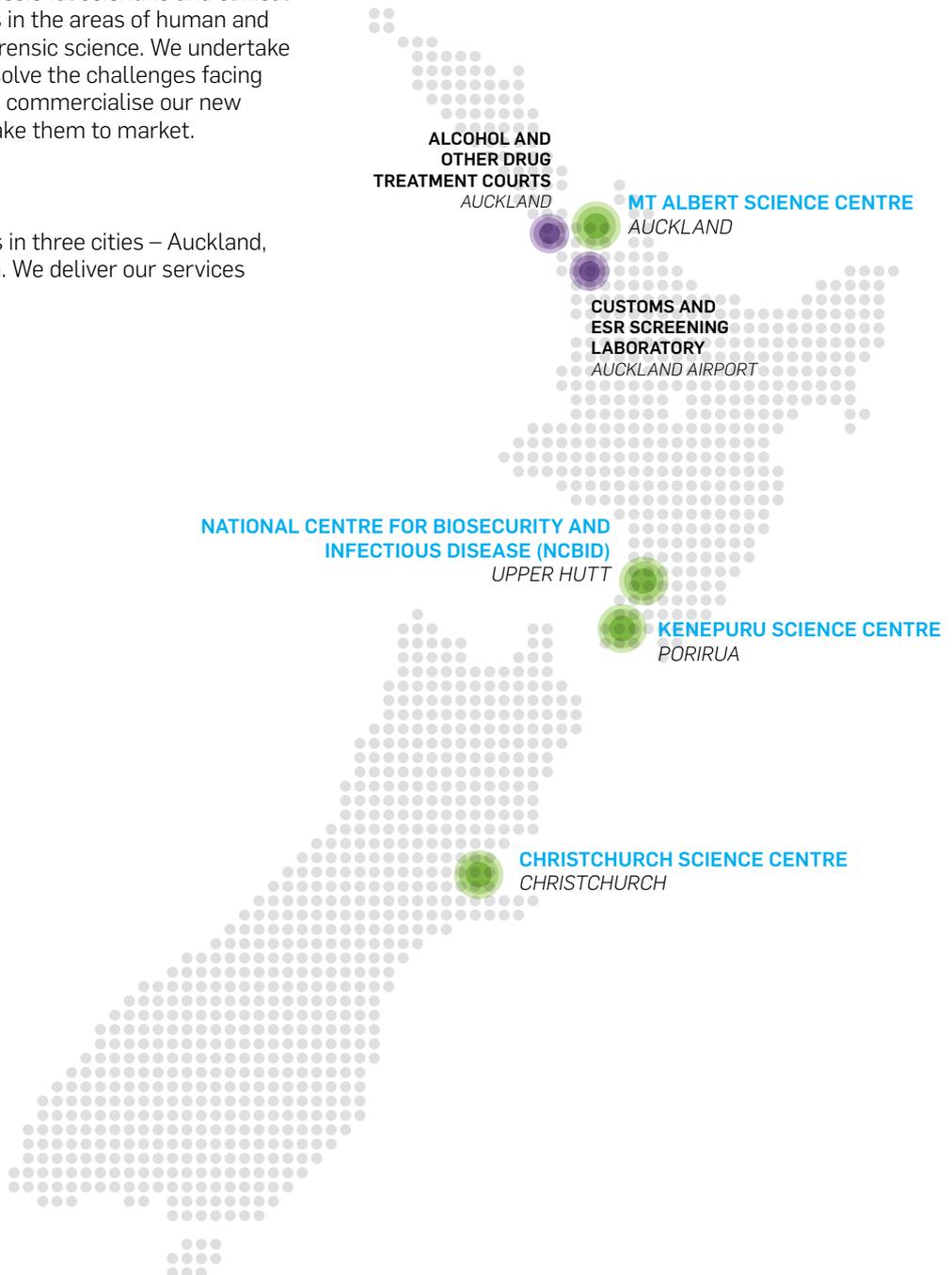
HOW WE WORK

ESR provides high-end, professional scientific and clinical services to a range of clients in the areas of human and environmental health and forensic science. We undertake innovative research to help solve the challenges facing New Zealand today. We then commercialise our new products and services and take them to market.

OUR LOCATIONS

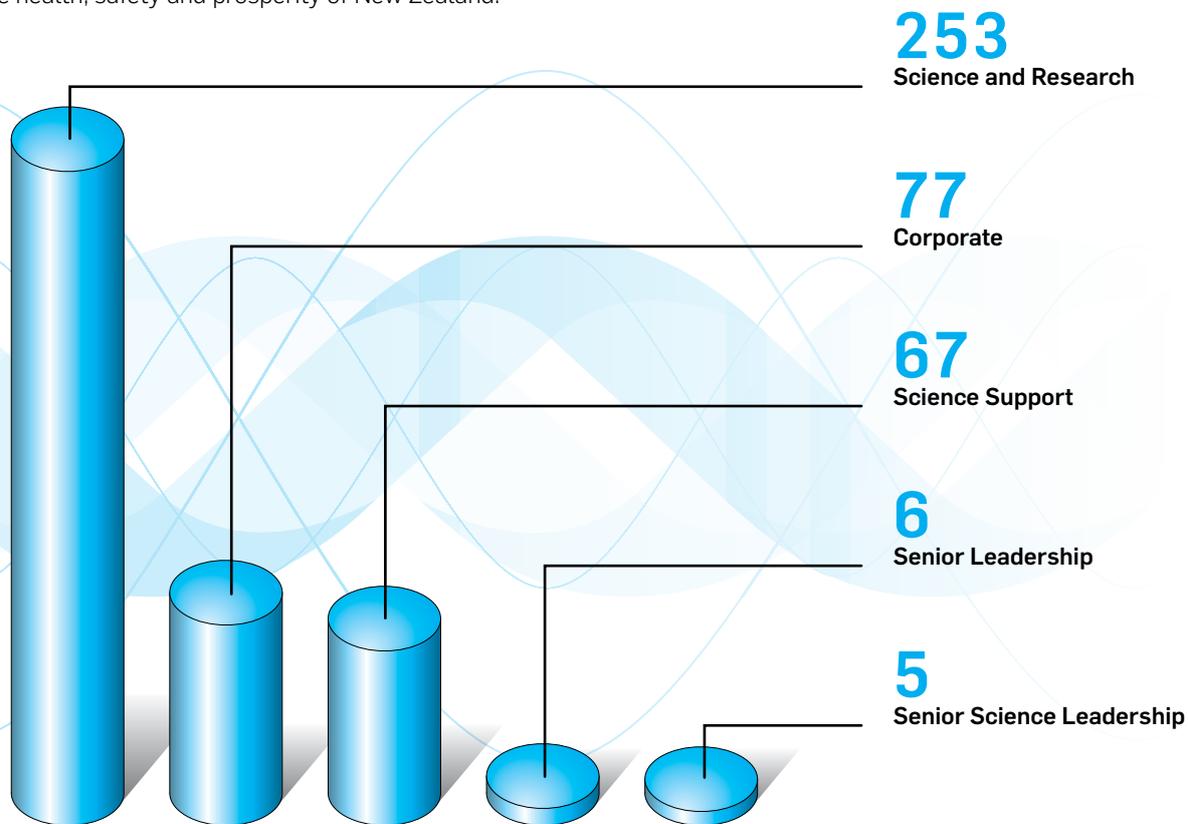
We work across six locations in three cities – Auckland, Wellington and Christchurch. We deliver our services worldwide.

Our world-class knowledge, research and laboratory services help our partners and clients solve complex problems and protect people in New Zealand and around the world



OUR PEOPLE

ESR employs 408 people committed to making a difference to the health, safety and prosperity of New Zealand.

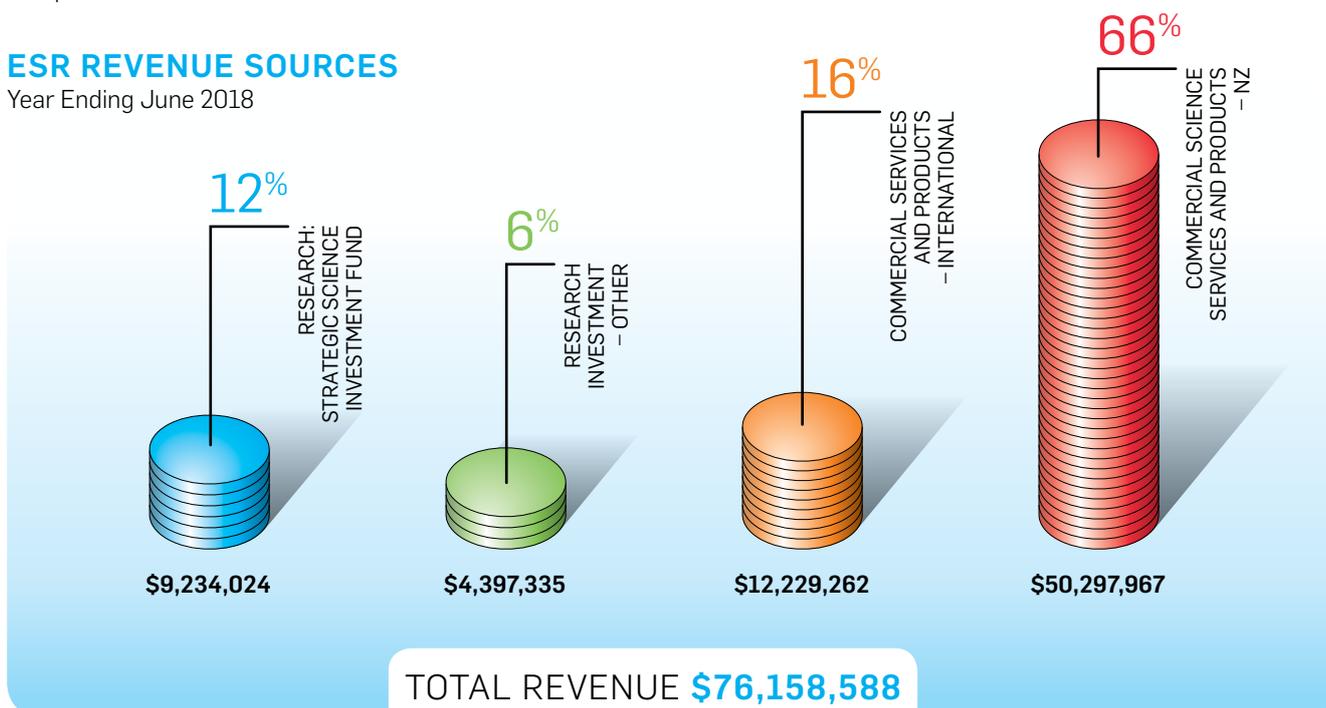


DELIVERING SUSTAINABLE GROWTH

As we deliver professional science services and undertake research for the public good, we are also keenly aware that for us to continue to grow and compete we must keep a sharp commercial focus on our business.

ESR REVENUE SOURCES

Year Ending June 2018



A YEAR IN HIGHLIGHTS

Key moments in our year

ESR acquired a stake in Kiwi biotech company **AuramerBio** – a start-up company that designs and develops aptamer biosensors

STRmix™ was established as a separate incorporated entity to increase its agility and flexibility.

Now in **52** labs around the world



ESR played a starring role for a second season in the **Forensics NZ** documentary series made by South Pacific Pictures.

E/S/R + + + = **EVIDENCE BASED POLICING CENTRE**

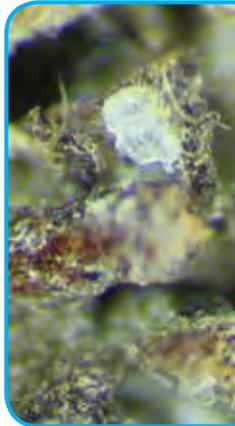
ESR joined forces with the University of Waikato, Police, their partners and Vodafone, to establish the Evidence Based Policing Centre. The world-class research centre helps to better inform Police in their work to prevent crime and protect the public.

The **Border to Grave** project, developed in 2017, looks at the link between new drugs coming in at the border and their real-time use and abuse in the community, including motor vehicle accidents, criminal cases, assessing drug-affected patients admitted to emergency departments, along with data derived from ESR's Drugs in Wastewater programme.

8 **Vision Mātauranga programmes in place** five of which were awarded at the end of the 2017/18 financial year.

E/S/R CELEBRATING **25** YEARS

Together with the six other Crown Research Institutes, **ESR celebrated 25 years of service** marked by a major conference displaying the many ways that Crown Research Institutes have made a positive contribution to New Zealand through science.



Forensic chemists and toxicologists played a key role in the response to a spate of synthetic cannabinoid-related deaths. ESR drugs and toxicology teams tested both the drugs and post-mortem samples to look for the key psychoactive substances associated with the cases.

ESR's forensic capabilities were showcased in Singapore at a presentation to the **Science and Technology Exhibition and Conference for Homeland Security**, hosted by the Ministry of Home Affairs.

ESR signed an agreement with the Singaporean Ministry of Home Affairs (MHA) to become a **preferred supplier**, allowing direct procurement of services and products such as blood pattern analysis training, laser scanning expertise and virtual reality content.



ESR scientists significantly improved the outputs of forensic laser scanning. The new applications enable the entire 3D crime scene, with embedded photographs or results, to be viewed. This conveys a scene to jury members more realistically and supplements the presentation of evidence.



Drones were introduced to ESR's arsenal of equipment enabling scientists to quickly produce an accurate 3D model of a large area from aerial images.

ESR incorporated the use of **virtual reality (VR)** as an investigation and training tool. The VR tool generates novel training environments, incorporating a wealth of 3D data from years of crime scene scanning, to produce VR investigative tools for training new Police detectives.



New Zealand
**FOOD SAFETY SCIENCE
& RESEARCH CENTRE**

Funded by the **New Zealand Food Safety Science & Research Centre**, ESR undertook a review of anticipated changes to New Zealand's food systems due to climate change and an assessment of biocide use and implications in the food industry.

Partnering with **AuramerBio**, ESR scientists developed a proof of concept for an aptamer-based assay to detect *Listeria* quickly and on site. They confirmed that, with refinements, the aptamer-based technology could be incorporated into a small sensor device for use in seafood-processing plants.

The Health Intelligence Team developed an internet-based influenza intelligence dashboard. On a near real-time basis, it provides a measure of the impact of influenza during the season. This includes information on current activity and severity and which influenza viruses are circulating in the season, along with demographic information and a breakdown of influenza by District Health Board.

As part of the Centre for Integrated Biowaste Research ESR is working with Ngā Muka Development Trust, Te Riu o Waikato Limited, Matahuru Marae/Nikau Whānau Farm Trust and Waikato Regional Council to create a monitoring system that will join western science with mātauranga Māori and taiao values. The monitoring system will measure the benefits of riparian vegetation restoration on the health and wellbeing of Lake Waikare.



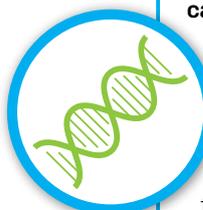
Funded by the United States National Institute of Allergy and Infectious Diseases, the **SHIVERS-II** study will gain insight into the immunity or protection people have against influenza through infection or vaccination. The study will also provide information that can be used to make better flu vaccines in the future.

ESR was commissioned by the **Ministry of Health** to produce a report showing how climate change could impact on New Zealanders' health.

ESR scientists developed technology to test the efficiency of filtration systems commonly used in community water supplies and domestic point-of-use filters. They developed tiny biomolecule-modified surrogates for disease causing organisms, *Cryptosporidium*, rotavirus, adenovirus, and norovirus. The harmless and inexpensive surrogates are tagged with DNA markers or dye to see if they are being removed by the filtering process.

10 years.

The National Centre for Biosecurity and Infectious Disease (NCBID) at Wallaceville celebrated



ESR increased its sequencing capacity by acquiring sample automation instruments to supplement the MiSeq and NextSeq550 DNA sequencing and cytogenomic microarray instruments. The new DNA robot automates DNA extraction from samples, and the fragment analyser performs the quality control check during sample preparation.

A YEAR IN REVIEW FROM THE CHAIR AND CHIEF EXECUTIVE



ESR's innovative science continues to impact positively on the lives of New Zealanders.

Some of the most pressing challenges that New Zealand faces include the threat of pandemics, antimicrobial resistance, proliferation of illicit drugs, violent crime and the contamination of our freshwater systems. ESR applies smart science to solve problems in these areas and help make a real difference to New Zealand today.

MEETING CHALLENGES WITH SMART SCIENCE

We are entrusted to deliver science services and research that help our clients meet their strategic goals.

In the public health area, our team of health scientists provide unprecedented insight and expert advice to help prevent and reduce disease, especially in the area of communicable or infectious disease. We continue to deliver world-class health surveillance services that are an integral part of the health system. Along with the many notifiable diseases we track, ESR maintains a number of surveillance systems to provide a timely and comprehensive understanding of respiratory virus activity and severity in New Zealand. Each week, through our new internet-based influenza intelligence dashboard, we provide real-time visualisations about the rate and severity of the influenza virus to help health agencies plan and respond.

Antimicrobial resistance is a growing global public health threat. ESR contributed to the development of the *New Zealand Antimicrobial Resistance Plan* in conjunction with the Ministry of Health and the Ministry for Primary Industries. As part of the plan, ESR has taken responsibility for work relating to strengthening the knowledge and evidence base about antimicrobial resistance through surveillance and research.

Our independent, internationally recognised forensic science service is a key part of the justice system and continues to solve crime and prevent further harm. This year, we dealt with over 10,180 criminal cases, processed over 42,267 exhibits and added 14,684 profiles to the DNA Profile Databank. Our scientists, technicians and crime scene specialists apply high-quality, leading-edge science to bring criminals to justice and ensure the innocent are not wrongly convicted.

ESR scientists routinely test samples for the presence of alcohol, illicit drugs and related materials. Our extensive expertise across the spectrum of drugs, alcohol and poisons means we can provide additional intelligence regarding composition, source and trends. Our forensic laboratories are accredited to one of the highest international standards for forensic laboratories.

ESR applies smart science to solve some of the most pressing challenges that face New Zealand society today



Every day, thousands of people, packages and large amounts of cargo arrive at the New Zealand border and enter the country. The Customs/ESR Screening Laboratory in Auckland is responsible for screening and identifying suspected drug samples seized by Customs at border security and through the international mail centre.

This joint venture between our two organisations has now been operating for over two years and is playing an important part in screening and identifying suspected drug samples. Given the continued, unrelenting appearance of new designer drugs at the border, there is ample justification for such a system to operate on a continual basis. With the increase in access to, and constant evolution of, designer drugs, real-time information is crucial.

Prevention of harm is one of ESR's guiding principles. Building on the pilot project commissioned two years ago by the National Drug Intelligence Bureau to test the biomarkers for drugs in the wastewater treatment plants in Auckland, Christchurch and Northland, ESR is now working with Police and the National Drug Intelligence Bureau to expand the testing throughout New Zealand. ESR's rigorous sampling method and expertise in analytical chemistry coupled with leading-edge technology meant that, for the first time, Police have a real-time, population-based understanding of drug usage patterns throughout New Zealand, providing them with a valuable intelligence picture.

Food safety is important for New Zealand. Food industry exports make a major contribution to our economy, and our ability to protect and increase our international trade in food products, as well as protect the health of New Zealanders,

depends on our food safety system. ESR helps assure New Zealanders and our trading partners of the safety and integrity of the food we eat and trade. We provide monitoring and diagnostic services to government and food industry clients. This year, we commenced three food research projects with our partners in the New Zealand Food Safety Science & Research Centre. This included work on biocides, capability mapping and a process hygiene index.

Clean and safe water is fundamental to a healthy New Zealand society. Improving the safety of freshwater and groundwater resources for human use is critical to the health and wellbeing of New Zealanders. Each year, we compile the *Annual Report on Drinking-water Quality* for the Ministry of Health. This year, we found that 81% of New Zealanders received drinking water that met all standards so there is still much work to do. Our scientists are coming up with novel ways to improve water treatment systems to make them more effective, such as the development of harmless surrogates that mimic the behaviour of disease-causing organisms and that can be tracked as they move through groundwater and freshwater systems.

INVESTING TO PREPARE FOR THE FUTURE

Over the past three years, we have steadily improved our financial performance and levels of stakeholder satisfaction. A good portion of our revenue is derived from nationally critical science services provided to government agencies, along with commercial clients both in New Zealand and overseas. We have been very successful at generating international revenue which now comprises 18% of our total revenue. Although we achieved a strong return on equity at 8.2% this year, earnings from our core contracts have been flat for a number of years, and along with the relatively low level of research funding received from government, our current model is not sustainable. The sustainability of our core contracts, appropriate levels of research funding and successful commercialisation of our intellectual property are fundamental to ESR's financial sustainability.



We have taken a number of actions to improve the financial viability of the business this year. We are making progress negotiating more sustainable contracts with our core clients so that customer needs are met in a viable way. We are actively growing our revenue so that we have the resources to invest in our business. So while this year's revenue is slightly ahead of last year's result at \$76.2 million, our net profit has levelled off as we increased investment in science capability, especially in genomics, data science and bioinformatics, leading-edge technology and equipment and designing our future way of working.

Changes in technology and science are offering new opportunities for not only how we deliver our science but also how we work across our network of science centres. This year, we have moved to address the deteriorating Kenepuru Science Centre, with a replacement facility being planned. This is an opportunity to develop facilities that encourage collaboration and innovation. Increased mobility, flexible workspaces and greater collaboration internally, and with our partners, will be part of our future ways of working. We will create fit-for-purpose science facilities that are responsive to future trends and science priorities, as well as enabling us to work across our specialisations.

NEW MARKETS, NEW PRODUCTS SUPPORT SUSTAINABILITY

We are leading development and implementation of research and technologies that bring about the growth of new services and capabilities and translating research into operational use. Our Pioneer Fund provides the seed funding for our scientists to take up the challenge to develop innovative ideas that will benefit customers and provide future revenue for ESR.



We are continually adapting and diversifying our business, developing new and innovative science that we can turn into products and services that we can bring to market. We have established our forensic software business, STRmix™, as a separate incorporated entity, which will enable it to increase its agility and flexibility and deliver STRmix™ and related products to our clients internationally. STRmix™ is now in 52 laboratories throughout the world and provides a significant portion of our international revenue.

Our CellTyper2 technology, based on RNA stable regions, has the ability to revolutionise the way we identify evidential samples. It continues to be developed as we look to commercialise this technology. Working with KiwiNet, market validation is well under way.

In 2017, ESR acquired a stake in Kiwi biotech company AuramerBio, a start-up company that designs and develops aptamer biosensors. An aptamer is a sequence of single-strand synthetic DNA that can bind to specific target molecules. They can be used to identify and quantify small molecules such as illegal drug detection and pathogenic bacteria detection. ESR is already exploring promising research opportunities involving aptamers including developing a *Listeria* detection tool for ready-to-eat seafood using an AuramerBio aptamer.



STRONG PARTNERSHIPS TO MAKE A DIFFERENCE

Our success is based on the strong partnerships we have formed with the core government agencies and research collaborators with whom we have worked closely for many years. In December 2017, we joined forces with the University of Waikato, Police and Vodafone to establish the Evidence Based Policing Centre. This world-class research centre helps to better inform Police in their work to prevent crime and protect the public. Our forensics research projects with them are many and varied and include 3D evidence visualisation for courts, the drug early warning surveillance system and RNA body fluid identification research.

As a key collaborator in the New Zealand Food Safety Science & Research Centre, we work with other research organisations and universities to produce an internationally credible science base for decision-making in public health and the food industry. Our work focuses on better ways of detecting hazards in the food production chain and reducing the risk of foodborne illness to consumers.

Along with Otago and Massey Universities, ESR is one of the lead partners in the One Health Aotearoa alliance, which brings together an integrated, cross-sectoral and whole-of-society approach to health hazards to address infectious disease issues across the animal, human, and environmental health sectors.

Bringing to life the principles of Vision Mātauranga through the development of He Tangata, He Pūtaiao, our Māori economy strategy, we are focused on realising Māori aspirations through science. The new strategy developed by the Māori Economy Manager sets out the way ESR will work with our Māori partners, ensuring that our research programme is aligned with Māori goals and that it is well resourced to achieve the aims of the strategy. A Māori

Research Leader has been added to the team, providing depth to the programme. ESR now has eight Vision Mātauranga programmes in place, five of which were awarded at the end of the 2017/18 financial year.

We have continued meeting with our stakeholder reference panel twice a year, enabling us to gain a deep understanding of the challenges our clients face. This includes partners such as Police, Customs and the Ministries of Health, Primary Industries, Environment, Justice and Foreign Affairs and Trade. Along with our trusted partners, ESR also works closely with universities, research collaborations and commercial organisations, actively seeking new relationships to further grow our science and research.

OUR MOST VALUABLE ASSETS – OUR PEOPLE

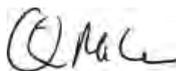
The greatest asset in any knowledge-based organisation is the expertise of its people. Our people are at the centre of our success. To ensure our organisation works at its optimum level, this year we improved the structure of the organisation merging two business groups into one unit. We invested in the capability and capacity of our scientists, clinicians and bio-informaticians focusing on data science, genomics and bioinformatics. More than one-third of our people travelled internationally attending conferences and committees. Our scientists published 68 articles on their research in prestigious journals, including ground-breaking science such as that emanating from the ESR-led Southern Hemisphere Influenza and Vaccine Effectiveness Research and Surveillance (SHIVERS) study.

This year, we also focused on telling our stories in the belief that 'science is not finished until it is communicated'. We have also grown our social media presence enabling us to reach a wider audience. Although much of what we do is behind the scenes, the impact ESR makes is substantial, and these stories are ones our clients, future clients, collaborators and the New Zealand public should hear.

Along with the other six Crown Research Institutes, ESR celebrated 25 years of service this year with a major conference that displayed the many ways that Crown Research Institutes' research has made a positive impact through science. For a small country, we certainly punch above our weight, and we at ESR are the embodiment of this as we strive to make a real difference to the lives of New Zealanders.



Denise Church, QSO
Chair



Dr Keith McLea
Chief Executive

Our success is based on the strong partnerships we have formed with core government agencies and research collaborators



02

OUR STRATEGY



Advances in science and technology are already providing significant opportunities to drive much greater value for our clients.

OUR STRATEGIC DIRECTION

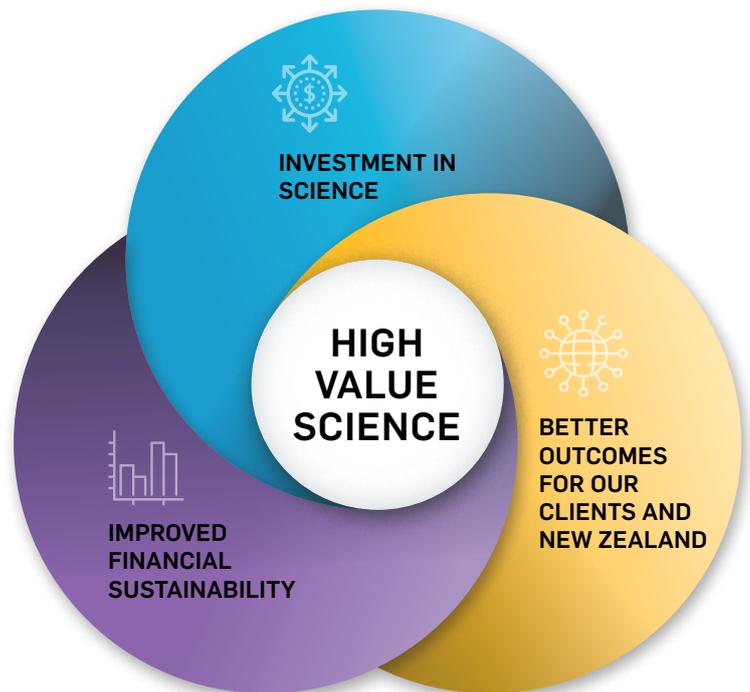
During the year, we reviewed our strategy to take account of future trends likely to impact on ESR.

Developments in genomics, data science and artificial intelligence are some examples of evolving trends that have the potential to significantly change how we deliver science to serve New Zealand communities.

Our refreshed strategy *ESR into the Future* sets out four strategic priorities critical to our future success, which we will use to guide investment.

OUR FOUR STRATEGIC PRIORITIES

Our four strategic priorities are essential to our future success



HARNESSING ADVANCES IN SCIENCE AND TECHNOLOGY

Advances in science and technology are already providing significant opportunities to drive much greater value for our clients.

During the year, we established a new DNA sequencing unit at Kenepuru and grew our bioinformatics capability, which is essential for interpreting the vast amounts of data produced. New genomic sequencing equipment and robots acquired during the year have significantly increased our capacity to process DNA samples. ESR now offers genome sequencing as a routine service to our clients.

Data science is another key capability ESR is growing to provide much greater insights for our clients. We initiated three projects that leverage our data using artificial intelligence and machine learning. These projects include a drug intelligence network, incorporating genomics and bioinformatics into public health surveillance, and analysing social media data to improve public health surveillance. Looking ahead, the ESR Board agreed to make a significant investment in data science capability, infrastructure and tools in 2018/19.



DRIVING GROWTH FOR REINVESTMENT

We are actively pursuing global opportunities for growth and reinvesting the profits we generate into our science capabilities, products and services for the benefit of New Zealand. Global sales of our world-leading forensic software STRmix™ continued to grow, with the first sale achieved in China. STRmix™ was transferred to a subsidiary company to provide the team with increased agility and flexibility to deliver STRmix™ and related products to our clients around the world.

Another forensic product we are developing is the use of degraded RNA transcript regions as targets for enhanced forensic body fluid identification. We have now developed the software and begun negotiations with overseas partners to further commercialise the technology. Separately, ESR worked with the University of Virginia on a project to take this product onto a microfluidics disk for rapid testing.

We continued to pursue other international opportunities for growth, particularly in Southeast Asia and the Pacific. ESR signed a Memorandum of Arrangement with the Chinese Research Academy of Environmental Sciences. The agreement will enable both organisations to partner across a wide range of technologies, testing methods and research to improve the environment.

Growing our research is a major focus as it will lead to new and enhanced products and services for our clients. During the year, ESR grew total research revenue by 20%. This included new research funded by MBIE Smart Ideas and the Health Research Council, as well as a grant from the prestigious Marsden Fund.

STRENGTHENING OUR ORGANISATIONAL RESILIENCE

We implemented several initiatives to ensure our science services, products and research continue to be backed up by a strong and resilient organisation.

ESR combined its Health and Environment business groups in early 2018 to create opportunities for greater collaboration and enhancement of joint services.

An indicative business case for replacing the ageing science facilities at Kenepuru was developed. The next steps are to develop a workplace strategy outlining how we will work in the future and develop a concept plan for the new science facilities.

We continued to invest in the development of our leaders to ensure they have the skills and mindset to build the capability of their teams, lead our culture and facilitate growth, change and innovation.



MAKING A GREATER DIFFERENCE FOR NEW ZEALAND

Increasing the impact our science makes for New Zealand is the ultimate goal of our strategy. As well as the impacts outlined in the outcomes sections that follow, we implemented strategic initiatives to strengthen our strategic partnerships, help create an Evidence Based Policing Centre, improve outcomes for Māori through Vision Mātauranga and adopt a One Health approach.

The main way we create impact for New Zealand is through strategic partnerships with government agencies. We gained a deeper understanding of the pressing challenges in the Health, Justice, Primary Industries and Environment sectors through ongoing discussions at our Stakeholder Reference Panel. We agreed a three-year Service Level Agreement with Police and began planning for the negotiation of a further agreement with the Ministry of Health.

ESR is a strategic partner in the Evidence Based Policing Centre, which uses an evidence-based problem-solving approach to identify ways to detect, prevent and disrupt crime. The centre was opened by the Minister of Police in December 2017, with initial research focusing on family harm, organised crime, making a difference to the frontline, and mental health.

ESR's science capabilities can contribute to better outcomes for Māori. As well as building enduring relationships with iwi, ESR is strengthening its internal capability to engage with Māori. ESR now has eight fully funded Vision Mātauranga projects, ranging from developing a food safety framework for mahinga kai to leveraging 3D technology to preserve our histories into the future. The amount of research we are committing to is significant and will provide us with opportunities to further develop relationships with iwi.

'One Health' describes the human-animal-environment perspective on health. Six out of every 10 infectious diseases in humans are spread from animals, and the study of these zoonotic pathogens is a speciality of ESR's Health and Environmental scientists. A new Science Centre, One Health Aotearoa, funded by Otago University, in conjunction with Massey University and ESR, was launched in August 2017.

The main way we create impact for New Zealand is through strategic partnerships with government agencies



GROWING OUR COMMERCIAL BUSINESS

ESR continues to grow the commercial side of the business, adapting and diversifying our products and transforming scientific research into marketable products and services.

Revenue increased this year from \$75.5 million to \$76.2 million. We are striving to increase our domestic business, working with our core partners as well as commercial businesses, local authorities and iwi to deliver high-end scientific services and research.

We contribute to the economic, environmental and social wellbeing of people and communities globally. Our forensic expertise is utilised by law enforcement agencies around the world, and our breakthrough forensic DNA analysis software STRmix™ can be found in leading laboratories, including the FBI.

Our expertise in public health, radiation monitoring, water quality, sanitation and hygiene practices, and food safety is utilised by our partners around the world.

TAKING OUR SCIENCE TO THE WORLD – INTERNATIONAL REVENUE



NEW ZEALAND-CHINA FOOD PROTECTION NETWORK

The New Zealand-China Food Protection Network aims to strengthen connections and create new collaborations between leading organisations and individual scientists in New Zealand and China engaged in food safety and security research and policy making. ESR was part of a delegation that went to China this year to further this aim, visiting an international forum on food safety, and attending a workshop with China National Cereals, Oils and Foodstuffs Corporation (COFCO), China's largest food processor, manufacturer and trader.

CHINESE HONOUR

Dr Keith McLea has joined the China Council for International Cooperation on Environment and Development (CCICED) as a Special Advisor. The CCICED is hosted by the Chinese Ministry of Environmental Protection (MEP) and seeks advice on critical environmental and developmental challenges for China and the global community. The CCICED is chaired by a member of the state council. ESR is greatly honoured by this invitation, which is an indication of the quality of the relationship we have with both MEP and the Chinese Research Academy of Environmental Sciences (CRAES).

SINGAPORE

ESR continues to develop a working relationship with the Ministry of Home Affairs (MHA) in Singapore. ESR's forensic capabilities were showcased at a presentation to the Science and Technology Exhibition and Conference for Homeland Security, hosted by the MHA.

In April 2018, ESR signed an agreement with the MHA that places ESR as a preferred supplier to them, allowing the direct procurement of services and products from ESR (such as blood pattern analysis training, laser scanning expertise and virtual reality content).

At the initial stages, an arrangement or memorandum of understanding was discussed to encourage a science and knowledge exchange, but this was graduated into an agreement when both parties realised the potential value of reciprocally purchasing expertise and services for mutual benefit. There have already been two exchange programmes between the agencies, with ESR scientists visiting MHA to study their Chemical, Biological, Radiological, Nuclear, and Explosive materials (CBRNE) expertise and MHA coming here to look at our DNA expertise. MHA also sponsored ESR participation at the Chief Science Advisors' meeting in Jordan.

CRAES RELATIONSHIP GROWS

ESR's relationship with the Chinese Research Academy of Environmental Sciences and the Chinese Ministry of Environmental Protection continues to grow with officials visiting ESR this year to discuss areas of collaboration. These have been identified as research in the areas of biowaste, point of source identification and attribution (pollution sensors/detectors) and One Health. All parties made a firm commitment at this meeting to follow through on the relationships and build strong research collaborations to address the areas agreed upon.



STRmix™ – A KIWI SUCCESS STORY

ESR's world-leading expert forensic software STRmix™ continues to go from strength to strength as more forensic laboratories across the world begin to use it.

STRmix™ is computer software that uses probabilistic genotyping enabling forensic scientists to identify individual DNA in crime scene evidence that contains up to five people's DNA. The software is recognised as a breakthrough in helping authorities solve criminal cases. Before STRmix™ scientists were not able to draw conclusions from complex mixed DNA samples, rendering much evidence inadmissible. The software can match mixed DNA profiles directly against a database. This is a major advance for cases where there are no suspects and the DNA is from multiple contributors in one sample.

STRmix™ was developed by forensic scientists, John Buckleton and Jo-Anne Bright from ESR in collaboration with Duncan Taylor from South Australia.

INTRODUCING STRmix LIMITED'S CHIEF EXECUTIVE – MARTIN RIEGEL



Martin Riegel, the new Chief Executive of STRmix Limited, has a background in biotechnology and IT and extensive experience working in growth technology companies in senior roles. Martin started as a software developer before moving into a wide range of financial and operational roles including 10 years at Intel. As Chief Operating Officer and Chief

Financial Officer of NextWindow, he played a lead role in engineering its sale to Smart Technologies in Canada. He has also served as Chief Executive at Biotelligia and as Principal of Broadfield Advisory.

STRmix™ NOW ITS OWN COMPANY

ESR has split STRmix™ from the main ESR operation to be a new subsidiary, STRmix Limited with governance provided by ESR. The new company has been set up to focus on growing STRmix™ and its associated products further and to better serve its international customers. Celebrating its sixth year of use in live casework, the product is under constant development, with each version adding new features to improve the offering. Version 2.6 is currently being rolled out.

STRmix™ continues to grow worldwide with 52 laboratories using it. In the United States, 36 US labs now routinely use the software in resolving DNA profiles. This includes federal agencies such as the Bureau of Alcohol, Tobacco, Firearms and Explosives and the FBI as well as state and local agencies. Another 50 labs are in various states of installation, validation and training. The breakthrough software is also being used in casework by laboratories in Australia, England, Scotland, Republic of Ireland, Canada, Finland and, of course, New Zealand.

STRmix™ HELPING SOLVE CRIME

Police in the town of Jupiter in Florida, USA, were at a loss for answers in the days and months after a triple murder on the day of the 2017 Super Bowl. A rifle, some bloodied items, gloves and clothing were found in and near a car stolen from the murder site. They were covered in blood and sweat. The DNA samples on those items were mixed and could not be discerned by the technology at the sheriff's office at that time. The acquisition of STRmix™ software by the Palm Beach County Sheriff's Office (PBSO) Forensic Biology Unit changed everything. It enabled the case to be cracked and arrests were made 10 months after the slaying. The frame of the rifle found by the car had 69% DNA contribution from Person A, 25% from Person B, and 6% from an unknown person. The hoodie found in the car had 53% of Person A's DNA, 33% of Person B's and 14% belonged to a third person. The two assailants have now been convicted and are safely ensconced in a Florida jail. PBSO's forensic scientists said the reason they picked STRmix™ was the quality of the training as well as the open way STRmix™ trainers showed PBSO analysts how the software program worked.

HE TANGATA, HE PŪTAIAO

REALISING MĀORI ASPIRATIONS THROUGH SCIENCE

ESR is committed to investing in and partnering with Māori to advance Māori aspirations and add value to Māori communities and assets through science. The mechanism through which we can deliver tangible outcomes is 'He Tangata, He Pūtaiao' – a strategy that uses science to grow the Māori economy.

ESR has embraced the concepts of Vision Mātauranga, which, at its essence, acknowledges that unlocking the potential of the Aotearoa New Zealand science system and partnering and leveraging Māori knowledge, people and resources will benefit all New Zealand.

He Tangata, He Pūtaiao is focused on and committed to working towards achieving these outcomes:

Concepts and intentions of Vision Mātauranga are deeply embedded in all aspects of ESR's operation.

Science and research capabilities at ESR are aligned with the aspirations of Māori in a way that adds value to Māori assets.

ESR staff are enabled and resourced to understand and engage confidently with Māori and ready to collaborate both internally and externally to maximise opportunities to work with Māori.

ESR invests in external organisational relationships to maximise opportunities to partner and collaborate with Māori.

Investment and activities associated with Māori are actively coordinated both internally and externally to achieve the outcomes of He Tangata, He Pūtaiao.



The strategy aims to realise an active programme of investment in partnership with Māori to advance their aspirations and add value to their communities and assets. We will identify areas of mutual interest, growth and co-innovation to support Māori, leveraging science as a key ingredient to ongoing social, cultural and economic development. To do this we need to grow our investment and strengthen our relationships with Māori iwi, hapū, rūnanga, businesses, Māori territorial authorities, government agencies, industry and Māori research organisations.

This journey builds on our previous work with Māori and has recently begun to pick up pace with the employment of a Māori Economy Manager.

Through developing ESR's internal capability to work in partnership with Māori, we will be better able to understand the challenges of primary concern and identify opportunities where we can work together with Māori communities.

Our Vision Mātauranga Capability Fund projects continue to provide opportunities to work on areas of mutual interest including mahinga kai, groundwater and cultural heritage.

Improving internal ESR infrastructure and processes to better support collaboration with Māori and across business groups at ESR, while investing in external relationships, will ensure ESR is able to take advantage of opportunities to partner and collaborate with Māori. A pilot project incorporating the concept of ohu, or a Māori-led think tank, has been established across the forensic/justice platform. This is designed to encourage thought-leadership and dialogue between Māori and ESR.

ESR is committed to the successful implementation of the 'He Tangata, He Pūtaiao' strategy acknowledging this takes both fiscal investment and organisational shifts in thinking and infrastructure. The recent employment of a Māori Research Leader provides more internal resourcing to further enable us to move forward with our strategy.



VISION MĀTAURANGA CAPABILITY FUND

Vision Mātauranga and partnering with the Māori economy is one of ESR's strategic priorities.

ESR continues to prioritise investment to deliver on Vision Mātauranga research and science for the benefit of Māori and New Zealand. This has resulted in eight distinct projects awarded to ESR under Vision Mātauranga – three are ongoing and five are in the start-up process.

HE AO HOU, HE ĀTEA HOU: ENGAGING AND PRESERVING OUR HISTORIES INTO THE FUTURE

Building on the work previously done with Matatā-based iwi Ngāti Rangitīhi to create a virtual marae visualisation platform, ESR's 3D capture and virtual reality visualisation experts are working with them to further explore how newer technology can create a complete, dimensionally accurate, full colour and photo-realistic record of the marae, taonga and history. The outcome will be a methodology and engagement process that can be replicated across other marae and significant sites, preserving the unique cultural heritage of each iwi and helping bring Māori knowledge, science and innovation into the present day.

MAHIKIA KAI HE POU HEREKA TĀKATA, HAERE AKE NEI, HAERE AKE NEI: VALIDATING THE MAHINGA KAI FOOD SAFETY FRAMEWORK

ESR has worked with tangata whenua on a number of projects around mahinga kai resulting in the mahinga kai food safety framework. ESR partnered with Ngāi Tahu communities to co-develop an environmental risk assessment framework to be used to determine if mahinga kai (wild food) at specific sites is safe for human consumption. This project provided the foundation for the development of live tools and information to inform gatherers on the food safety of mahinga kai. The framework aims to ensure all mahinga kai gatherers are fully informed about the safety of the food they gather in different sites around New Zealand. A Te Rūnanga o Ngāi Tahu mahinga kai scientist has been placed at ESR to validate the framework across multiple mahinga kai sites within the Ngāi Tahu rohe (region) in the South Island. Among other things, the work includes validating the framework, and developing monitoring and sampling plans for issues such as how rainfall, water temperature, wastewater discharge and livestock affect the suitability of the consumption of mahinga kai.

HE PĪ KA RERE, HE TAUIRA KA REA: ADVANCING MĀORI ACHIEVEMENT IN SCIENCE

A collaboration between ESR, Massey University Pūhoro STEM Academy and participating schools will strengthen and broaden the reach and science offering of the Academy. The Academy aims to raise Māori participation and achievement in the areas of science, technology, engineering and maths by engaging with secondary school students from years 11–13. As ESR develops its relationship with the Academy and its students, we will integrate our science capability into

the Academy's curriculum. A mentoring programme between ESR and the Academy's alumni will also be developed along with a pre-university internship programme.

E RERE TE WAI E, PUPŪ AKE TE MĀTAURANGA: A CONVERGENCE OF MĀORI AND WESTERN WATER KNOWLEDGE SYSTEMS

New Zealanders get 40% of their drinking water from groundwater, so it is important that this resource is well understood. This project brings Māori groundwater science experts together to work with western scientists to develop new knowledge that brings together both systems. The aim is to codify Māori groundwater knowledge that has been gathered from pūrākau (legends), tikanga (customs), mātauranga (Māori knowledge) and intergenerational observations to advance the knowledge of New Zealand's groundwater systems. A forum will be established to bring these two science systems together.

NGĀI TAHU LIVING STANDARDS PROGRAMME

The Social Systems team is working with Te Rūnanga o Ngāi Tahu on a Vision Mātauranga Capability Fund project to develop a Ngāi Tahu living standard that reflects Ngāi Tahu aspirations. The aim of the project is to explore the potential for the principles of systems thinking and next generation social investment to contribute to Ngāi Tahu 2050 tribal development and investment strategies. The team includes researchers and experts from Motu Economic and Public Policy Research, Victoria University of Wellington and the Ngāi Tahu Research Centre.

HE PŪTAIAO KI TUA: SCIENCE BEYOND THE CLASSROOM

This project connects Te Pā o Rākaihautū school (Te Pā) and ESR so we can develop a long-term sustainable relationship where ESR scientists and Te Pā staff, students and the wider Te Pā whānau can learn from each other. Te Pā is a unique 21st century pā wānanga in Ōtautahi committed to educational success for the whole whānau. They have developed a high-level Te Taiao strategy that outlines key pou (anchor points). Two of the key pou are waste and wai Māori. The synergy between Te Pā's Te Taiao strategy and the science of ESR is aligned. The relationship between ESR and Te Pā will be advanced through co-developing kaupapa that explores biowaste and wai Māori through both mātauranga Māori and western science and supports Te Pā's Te Taiao strategy.

USING MĀNUKA AND KĀNUKA TO IMPROVE WATER QUALITY

ESR is working with Ngā Muka (Waikato-Tainui), Ngāti Kahungunu ki Wairarapa and Ngāi Tahu to explore the potential of the antimicrobial properties of mānuka and kānuka to improve water quality. We have already demonstrated that mānuka and kānuka root systems are able to significantly reduce leaching of nitrate compared with other riparian planting options.



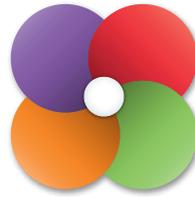
OUR IMPACT



ESR works across four key areas – public health, forensics, food safety, and water and the environment – to deliver better outcomes for New Zealanders and the communities in which we all live.

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ESR works across four key areas – public health, forensics, food safety, and water and the environment – to deliver better outcomes for New Zealanders and the communities in which we all live.



OUTCOME
1

HEALTHY COMMUNITIES

Safeguard the health of New Zealanders through improvements in the management of biosecurity and threats to public health.

IMPACTS

- Spread of infectious diseases is reduced
- Communities are protected from harmful contaminants
- New Zealand is able to respond to disease outbreaks

OUTCOMES

- Health interventions and policies that limit the spread of disease are informed by national disease surveillance and reporting
- Responses to disease outbreaks are informed by intelligence including the characteristics and epidemiology of the disease
- Responses to national emergencies affecting human health are informed by scientific information and advice
- Border protection policies are informed by disease surveillance trends

OUTCOME
3

SAFER FOOD

Enhance protection of New Zealand's food-based economy through the management of food safety risks associated with traded goods.

IMPACTS

- Food exported from New Zealand is safer
- Food consumed in New Zealand is safer
- Episodes and outbreaks of foodborne illness are diagnosed and mitigated

OUTCOMES

- New Zealand food exporters are better able to meet requirements for entry into key international markets through biological and radiation testing
- Management of food safety risks (biological and chemical) by government and industry is informed by scientific testing, research, projects and advice

*Delivering better outcomes
for New Zealanders*

OUTCOME

2

**SAFE
COMMUNITIES**

Increase the effectiveness of forensic science services applied to safety, security and justice investigations and processes.

IMPACTS

- More crime is solved
- Reoffending is reduced
- Harm caused by illicit drugs is reduced

OUTCOMES

- Criminal investigations are informed by analysis of DNA evidence and physical evidence at crime scenes
- Court proceedings are informed by testimony of expert forensic witnesses
- Decisions to intercept imports are informed through enhanced detection capability and drug surveillance trends
- Better intelligence on illicit drugs through information on specific drugs and illicit drug trends
- Police interventions to prevent crime are informed through Evidence-Based Policing research

OUTCOME

4

**CLEAN
WATER AND
THE ENVIRONMENT**

Improve the safety of freshwater and groundwater resources for human use and the safer use of biowaste.

IMPACTS

- Safer drinking-water
- Rivers, streams and groundwater are less contaminated
- Sustainable reuse of biowaste is improved

OUTCOMES

- Drinking water standards and policies are informed through scientific advice to the Ministry of Health
- Local authorities, industry and the Ministry for the Environment are informed on water quality issues through research, projects and advice
- Initiatives to reduce contamination of waterways are informed through research and science advice to landowners and local authorities
- Initiatives to improve the safe use of biowaste are informed through research



FORENSICS

HELPING PREVENT AND SOLVE CRIME

INCREASING THE EFFECTIVENESS OF FORENSIC SCIENCE SERVICES APPLIED TO SAFETY, SECURITY AND JUSTICE INVESTIGATIONS AND PROCESSES.



35,745
Drugs/Clan Lab casework



70%
DNA samples from crime linked to a person



32%
DNA samples from crime linked to other crimes



24,367
toxicology tests performed



11,541
blood alcohol tests



42,267
total number of exhibits processed

ESR provides world-class forensic science services and research to a range of New Zealand and international government agencies and private corporations. ESR is the sole provider of forensic services to Police and works closely with Customs to aid their processing at the border with scientific advice and analysis.

Our forensics laboratories in Auckland, Wellington and Christchurch provide Police with an on-call crime scene examination service, 24 hours a day, seven days a week. We also operate analytical laboratories that analyse samples in the areas of biology (DNA and RNA), physical evidence (paint, glass, fibres, fire debris, shoe prints and so on), illicit drugs, toxicology, breath/blood alcohol and workplace drug testing.



DESIGNER DRUGS – A REAL PROBLEM IN NEW ZEALAND

With the emergence of party pills or legal highs in the past decade, new psychoactive substances have become a real problem in New Zealand and around the world. A new designer drug is often an analogue (a compound having a structure similar to that of another compound, but differing from it in respect to a certain component) of a controlled substance. It has been designed to mimic the pharmacological effects of the original drug, while avoiding classification as a controlled substance or detection in basic tests for drugs.

ESR's analytical chemists and forensic toxicologists have identified more than 120 new designer drugs over the past three years. The drugs are almost exclusively manufactured overseas, many in China, and the sheer number of new drugs, their chemical diversity and the speed of their emergence make them challenging in terms of detection, monitoring and responding. Little is known on their effects or potency, leading to a clear danger through intoxication or even death. The Customs/ESR Screening Laboratory in Auckland, which opened in 2014, screens and identifies suspected drug samples from the thousands of packages and large amounts of cargo that come through the border every day. This collaborative venture has proved its worth in assisting Customs to protect our border.

RESPONDING TO THE SYNTHETIC CANNABIS CRISIS

ESR's forensic chemists and toxicologists played a key role in the response to the spate of synthetic cannabinoid-related deaths during the second half of 2017. ESR Drugs and Toxicology teams tested both the drugs and the post-mortem samples to look for the key psychoactive substances associated with the cases. ESR has extensive capability in the ability to detect a wide range of most recently identified synthetic cannabinoids and was able to quickly identify the drug associated with these cases. The most commonly detected type of cannabinoid in the laboratory is the psychoactive drug AMB-FUBINACA, which is 75 times more potent than THC, the active ingredient in natural cannabis. This drug has a serious impact on people's health, with an alarming number of deaths being attributed to it. AMB-FUBINACA is a complex molecule, synthesised in unknown laboratories, very likely manufactured overseas and smuggled into New Zealand.

MONITORING SYNTHETIC CANNABINOID TRENDS

ESR monitored synthetic cannabinoid trends throughout the year. This included monitoring samples intercepted at the border by Customs and submitted to the Customs/ ESR Screening Laboratory, Police evidential samples, and drugs from an ESR-funded initiative called Project Sinnie where street samples seized by Police but not needed for evidence, were analysed. A total of 10 different synthetic cannabinoids were detected, with those at the border being in powder form and those from the street being plant material. ESR also mapped the drugs by location to see the patterns emerging from different distribution networks.



A DRUG EARLY WARNING SYSTEM FOR NEW ZEALAND

The proliferation of new psychoactive substances poses a significant risk to public health. Those in the sector have called for an early warning drug surveillance system, and ESR is using its expertise to support the development of a national drug early warning system (DEWS). A national DEWS would detect and publish information about currently circulating drugs so enforcement, health and justice agencies can take action and consumers can make informed decisions before taking them. When a highly dangerous substance is detected, protocols will be in place to issue alerts. These can be rapidly and widely shared to help people avoid anything that is dangerous and thereby prevent harm.

ESR's Border to Grave project, developed in 2017, provides the start of a framework for a New Zealand drug intelligence surveillance system by gathering data from new psychoactive substances identified across ESR's drug-testing activities. The project looked at the link between new drugs coming in at the border and their real-time use and abuse in the community including motor vehicle accidents, criminal case work and drug-affected patients admitted to emergency departments, along with data derived from ESR's Drugs in Wastewater programme. This successful project provided very useful insights into psychoactive drug patterns and trends for those working in the field, including new synthetic cannabinoids and opioids such as fentanyl and its analogues. This led to developing an approach to a New Zealand DEWS. Leveraging off its proven expertise in data science and surveillance, ESR's DEWS mechanism will collect and analyse data around trends in drug availability, emergence, prevalence, usage patterns and harm, particularly with regard to time and location by drawing information from a variety of alternative sources, such as emergency rooms and social media, ensuring that emerging knowledge about new drugs is easily accessible.

DRUGS IN WASTEWATER PROGRAMME PROVES VALUABLE



ESR's wastewater drug testing programme is proving very valuable to Police. The programme maps drug-use patterns in communities, providing much more accurate data than can be achieved through self-reporting or drug seizures. It was commissioned in late 2016 by the National Drug Intelligence Bureau with initial testing sites in Auckland and Christchurch. Northland was added in late 2017. Combining ESR's expert capabilities in drug forensics, environmental chemistry, metabolism and biowastes, the wastewater sites are sampled over seven consecutive days each month, allowing for drug-use patterns to be identified both daily and for the longer term. Instead of taking months or years to test and analyse thousands of samples of urine, the drugs epidemiology programme, through analysing biomarkers excreted into wastewater, can provide results about drug use in a community in near real time, enabling interventions that could save lives. The findings enable Police and other agencies such as Customs and the Ministry of Health to better understand drug-use patterns in the population. The initial studies will be used as a baseline for future results.

The epidemiology of wastewater is a burgeoning science, and drug use sampling is just one application. For example, a Norwegian study compared methamphetamine rates in wastewater with hospitalisations from psychosis, while a UK study investigated the state of public health in a catchment area simply by measuring stress biomarkers.

FORENSICS PLAYS A STARRING ROLE

For the second time in three years, ESR played a starring role in the South Pacific Pictures *Forensics NZ* documentary series, which explores the world of forensic science solving real crimes in New Zealand. ESR forensic scientists were featured weekly with Police, as they re-enacted crime scenes.

Many of the forensic techniques used by ESR were highlighted including DNA profiling, blood splatter analysis and physical crime scene evidence. The public interest in ESR's work in this area is high with the programme once again being Prime TV's top-rating show for the season, pulling in between 96,000 and 145,000 viewers each episode.



USING SCIENCE TO MAKE OUR COMMUNITIES SAFER

ESR and the University of Waikato joined forces this year with Police and Vodafone to establish the Evidence Based Policing Centre (EBPC). The EBPC, which opened in December, is a world-class research centre, based in Wellington, to help better inform Police in their work to prevent crime and protect the public.

Evidence-based policing is a method of using data to inform decision-making about what works and which practices and strategies accomplish Police missions most effectively. In contrast to basing decisions on theory, assumptions, tradition or convention, an evidence-based approach continuously tests hypotheses with empirical research findings.

Four research themes have been established to define the research focus of the EBPC – organised crime, family harm, mental distress and improving the frontline. The breadth of ESR's research capabilities will enable us to be an active participant in the projects that contribute to the progression of these themes.

EVIDENCE BASED POLICING CENTRE

Our developing early work programme

First six months...

- Optimising DNA sample collection review
 - Drugs in waste water reporting
- Crime Harm Index implementation
 - Woolf Fisher Police Fellowships awarded
- Prevention First toolkit development
 - Victim video statement evaluation
- Casework data analytics
 - Prison violence / gang reoffending study
 - Mobile police base evaluation
- Youth offending trajectory analysis
 - Burglary offender profiling
- Lessons learned database development
 - Reoffending neighbourhood factor analysis
- e-Forms development
 - CCTV aggravated robbery footage review

First twelve months...

- Whāngaiā Ngā Pā Harakeke evaluation
 - Predictive policing model development
- EBP training for frontline police
 - Family violence data / case analysis
- Bail check effectiveness evaluation
 - Iwi panels evaluation
- Forensic analysis e-learning development
- RNA body fluid detection development
 - Ghandi Nevis initiative evaluation
- Border to grave drug surveillance model development
 - Sexual assault forensic intelligence analysis

First two years...

- 3D evidence visualisation development (for courts)
 - Intel vs evidence method development
- Bayesian network statistical model development (for comparative evidence)
- Drug protective group predictive analytics
 - Meth interventions analysis and development
- Burglary target hardening trial evaluation
 - Automated shoeprint analysis
- Suicide and prior Police contact analysis
 - Vein pattern identification analysis
- Genomics next generation sequencing

KEY
 Potential initiative partnerships: ■ New Zealand Police ■ University of Waikato ■ ESR

ELECTRONIC FORMS IMPROVE SEXUAL ASSAULT EXAMINATION PROCESS

Sexual assault is a crime that involves a wide range of offending from indecent assault to rape. Once a sexual assault complaint has been laid, Police may arrange for the victim to see a specially trained doctor who will provide medical assistance and carry out a forensic examination. As medical doctors conduct examinations, they follow set procedures that are provided as part of the medical examination kit. Evidence such as clothing and other items are sent to ESR for forensic testing. The medical

examination record forms capture all details about the assault. They are cumbersome carbon-copy forms that need to be filled out in triplicate. This year, in partnership with Medical Sexual Assault Clinicians Aotearoa (MEDSAC), ESR developed a more user-friendly, efficient way for doctors to make notes about their examination using a fillable pdf form on their tablet/computer screen. The new collection method, which is in prototype, has the ability to record all examination result data entered in a way that not only makes it easier to process but retains the chain of custody and is less intrusive for the victim.

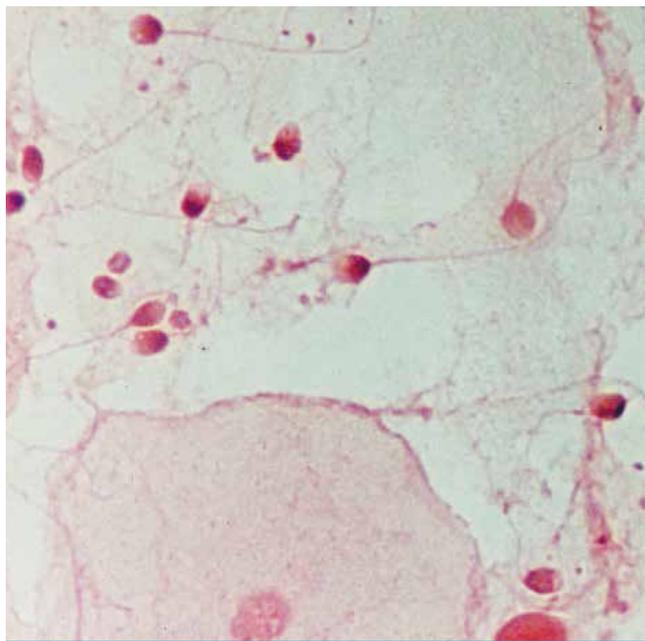
ADVANCES IN LASER SCANNING AND THE EMERGENCE OF VIRTUAL REALITY

ESR is a world-leader in applying 3D technologies to its crime scene investigations. We have been laser scanning crime scenes since 2012, and just recently, scientists have improved the outputs, which have been rolled out to Police. These new applications allow viewing of the entire 3D crime scene with embedded photographs or results which can better convey the scene to jury members and supplement the presentation of the scientist's evidence in court. To complement this laser data, the introduction of drones to ESR's arsenal of tools enables scientists to quickly produce an accurate 3D model of a large area from aerial images. Laser scanning has also been heavily utilised outside of forensics this year. A large project with a dairy organisation involved scanning two milk processing plants and work was undertaken for Plant & Food Research scanning multiple orchards for use in their research programme.

As well as the 3D laser scanning of crime scenes, more recently, ESR has incorporated the use of virtual reality (VR) as an investigative and training tool. We are working with a number of leading VR companies in New Zealand on how this technology can be applied to forensics. This includes generating novel training environments and incorporating the wealth of 3D data from years of crime scene scanning to produce VR investigative tools for training new detectives within Police. We are also working with other groups and researchers on VR technologies, including visually preserving Māori cultural assets with Ngāti Rangitīhi and engaging with South Australian psychology researchers to investigate the use of VR in crime scene comprehension. In house, this technology is further being investigated for its use in training our own scientists in blood pattern analysis interpretation, and VR will undoubtedly continue to grow with improvements in technology over the coming years.



USING RNA TO IDENTIFY BODY TISSUE



Several years ago, ESR became one of only a few forensic laboratories around the world to offer a body fluid identification test. The CellTyper test enables detection of a body fluid, such as saliva, circulatory blood, menstrual fluid, vaginal material and semen, in addition to DNA profiling. This year, ESR launched an updated version of the original test called CellTyper2.

The test is an RNA (ribonucleic acid) based technique. In the past, RNA was considered less stable than DNA as it degrades rapidly on cell death, limiting its use for diagnostic purposes. However, ESR scientists discovered that some parts of RNA actually do remain stable in organisms, tissues and fluids over time.

Using these stable regions of RNA, a new ground-breaking genomics tool has been developed by ESR scientists. This will now enable the identification of body fluids, tissues and cells using RNA for a much broader range of samples, specifically those that are older or compromised by environmental effects where it would not have been possible to obtain results in the past. In addition, ESR scientists and senior software developers have worked together to develop a well packaged computer program that forensic biologists can use to analyse body fluid results.

An example where RNA can be used is where a female is missing, presumed murdered, and bloodstaining is detected on her bedding. Her ex-partner states that the female had her period. The test can be used to identify whether the blood is menstrual or circulatory, thereby differentiating between these two body fluids.

The discovery has impacts outside forensic use too. For instance, in the health field, ESR scientists are collaborating with other researchers in areas such as identifying concussion in sports players earlier than is currently possible, helping determine the longer-term effects of concussion and swifter detection of endometriosis through tissue sampling rather than invasive surgery. The work could also help develop new diagnostic tests and services that will be more sensitive than any currently available.

DIVING INTO THE DARKNET



The darknet is an encrypted online network in which hidden marketplaces, known as cryptomarkets, have been set up to facilitate the anonymous trade of illicit drugs and other licit and illicit commodities. According to the United Nations Office on Drugs and Crime, the darknet market has been growing rapidly in recent years. As the popularity increases, more and more drugs purchased via the darknet will cross the New Zealand border, so prior information regarding online drug trends is invaluable to enable ESR and Customs to be better prepared to identify the presence of controlled drugs. ESR is developing in-house capabilities to extract relevant information and undertake trend analysis using darknet data. Trend analysis will include drug types, quantity, frequency and trends over time. Along with this, we are investigating how to assess the most efficient way to extract darknet data in real time to analyse drug trends.

EMBRACING MACHINE LEARNING TO AUTOMATE FORENSIC ANALYSES



The domain of artificial intelligence (AI) is constantly growing, and ESR is exploring it in the forensic laboratories. A purely mathematical-based tool, AI has the potential to support the development of automated workflows in forensic analysis. Machine learning (ML), a type of AI, is being investigated to determine its suitability for the partial automation of a technique in drug analysis utilising current infrastructure.

This ESR project focused on developing methods to assist scientists with the analysis of routine methamphetamine samples and tested the potential for ML to streamline the throughput of these cases.

ERECTILE DYSFUNCTION PRODUCTS TARGETED BY PHARMA PROGRAMME



ESR's pharmaceutical analysts have investigated a large range of erectile dysfunction products (Viagra and Cialis look-a-likes) that were intercepted at the border. Working for Medsafe, the organisation responsible for the regulation of medicines and medical devices in New Zealand, scientists set out to determine whether these were legitimate products or counterfeit or adulterated medicines.

Counterfeit medicines are a growing problem in many countries and are increasingly being supplied over the internet. Erectile dysfunction drug counterfeits are well documented internationally, and this project was initiated to look at the content of these products as well as investigate other quality standards.

USING GENOMICS TO TRANSFORM FORENSIC SCIENCE



ESR has embraced the genomics revolution transforming existing forensic DNA tests to massively parallel sequencing (MPS). This will allow us to test many more DNA sites simultaneously and uncover genetic variation within existing markers. This year, the groundwork was laid for the validation of new service offerings. Activities included enhancing bioinformatics and statistics capability to enable a full validation of genomics sequencing technology.

Our research has included using MPS to uncover ancestry informative markers on the X, Y and autosomal chromosomes and the mitochondrial DNA (mtDNA), enabling us to categorise individuals based on their genetic ancestry at a continental level. We are carrying out further research on validating methods for predicting physical traits such as hair and eye colour. MPS also allows the full mtDNA sequence to be determined from samples including very degraded bones and short fragments of hair, which are difficult to analyse currently. We are also using epigenetics to estimate the age of a person, which will be helpful in predicting physical traits that vary with age such as hair colour. AI and other statistical tools are being investigated as analysis tools to assist in the interpretation of our research data.

Operationalising this work also includes evaluating different DNA kits, defining operational requirements and setting up training programmes. These and other steps will complete the introduction of new service offerings in 2019.

FOCUS ON OUR EMERGING SCIENTISTS

REBECCA RICHARDS



Rebecca Richards is a first-year PhD student enrolled in the forensic science programme at the University of Auckland, supported by an ESR Vision Scholarship. She holds a Bachelor of Science (Biochemistry) and a Bachelor of Commerce (Marketing Management) from the University of Otago as well as a PGDip (Forensic Science) and an MSc (Forensic Science) from the University of Auckland. She has been based at the Mount Albert Science Centre in the Forensic Biology group for the past two years, first as a master's student, and then a PhD student.

Her research investigates how DNA methylation could be used for forensic applications. She also spends one day a week working as a senior technician in the Forensic Biology Laboratory.

DNA methylation is a modification of the genome, changing how genes are expressed without changing the underlying DNA sequence. The use of these modifications as biomarkers displays considerable promise for estimating chronological age differentiating between identical twins.

Information such as the age of a body fluid donor provides investigators with important intelligence information, as well as providing context to physical characteristic markers such as hair colour. Differentiation of identical twins could be of considerable benefit, determining whether a crime scene sample originates from a suspect or their identical twin.

In New Zealand, the DNA Profile Databank contains profiles from many sets of twins and triplets that cannot be distinguished when profiles are recovered from crime scene samples and a person is identified. Preliminary research completed as part of Rebecca's MSc degree together with international research has shown this method to have great potential in these applications.

Understanding how variation between people, different body fluids and other environmental factors influence methylation also forms part of Rebecca's research, with a view to providing a technique that is suitable for forensic casework.

Rebecca has already published a paper on this subject: Richards, R., Patel, J., Stevenson, K., & Harbison, S. (2018). Evaluation of massively parallel sequencing for forensic DNA methylation profiling, in the *Electrophoresis* journal.

FOOD SAFETY

PROTECTING NEW ZEALAND'S FOOD

ENHANCING PROTECTION OF NEW ZEALAND'S FOOD-BASED ECONOMY THROUGH THE MANAGEMENT OF FOOD SAFETY RISKS ASSOCIATED WITH TRADED GOODS.



831

radiation-free certificates issued for food exports



270

food and beverage samples examined for chemical and microbial hazards



127

suspected episodes of food poisoning investigated



240

food forensics investigations

The reputation of New Zealand's multi-billion-dollar food industry depends on the quality of the food we produce. Food industry exports make a significant contribution to the New Zealand economy. Being able to protect and grow our international trade in food products, along with protecting the health of New Zealanders, depends on our food safety system. ESR plays a vital role in the management of risks, helping to ensure our food is safe to eat and to export.

Our role in New Zealand's food safety system spans the full spectrum of food science services as we work with bacterial, viral, chemical, physical and radiological hazards. ESR specialises in reference-level assays (investigative procedures to measure such things as the presence, amount or functional activity of a target entity), new assay development and cutting-edge food research. We provide a range of services to the Ministry for Primary Industries, the Ministry of Health and the food industry to avoid, detect, mitigate and respond to foodborne hazards.



WORKING TOGETHER FOR SAFER FOOD

ESR continues to build its relationship with the New Zealand Food Safety Science & Research Centre (NZFSSRC). The centre was established in 2016 to protect and enhance New Zealand's reputation for world-leading food safety. A virtual centre harnessing the knowledge of some of the best scientists from around the country, it is a collaboration between seven research organisations – Massey University, the University of Auckland, the University of Otago, ESR, Plant & Food Research, AgResearch and the Cawthron Institute. Each is responsible for developing projects under different research themes and capability platforms. ESR is responsible for the risk landscape platform with the aim of growing fundamental proactive and reactive research into food risk safety analysis, making that research more publicly accessible and ensuring more young scientists enter this field.

One of the first projects completed by the NZFSSRC was to map food safety research capabilities across New Zealand. It found that Crown Research Institutes and universities held the majority of food science expertise, along with government agencies, especially the Ministry for Primary Industries. The expertise has been captured in a searchable database (www.nzfssrc.org.nz/resources).

During the 2017/18 year, ESR was involved in a number of research projects funded through the NZFSSRC including a review of anticipated changes in the New Zealand food system due to climate change and assessment of biocide use in the food industry and its implications.

FINDING THE SOURCE OF THE HEPATITIS E VIRUS

The hepatitis E virus (HEV) is a highly successful virus able to infect humans and animals. Most human infections do not cause illness, but for those who do develop hepatitis E, the disease can be very serious. In developed countries, hepatitis E cases have historically been travellers returning from developing countries where HEV is endemic. However, there are increasing numbers of people identified with HEV infections who did not travel to any developing countries. Those who become ill are often older men who are immunocompromised or have liver disease. Along with the Ministry for Primary Industries, ESR has contributed to international efforts by reviewing possible transmission routes to identify how people are being infected in developed countries.

Our scientists conducted a review, published in *Food and Environmental Virology*, that found swine, and meat and offal from swine, are likely sources of HEV infection. This is in agreement with other published work, however our researchers noted that a large body of work had focussed on this established HEV reservoir. Information on HEV in other animals and foods was far scarcer but tantalising, suggesting that other domesticated animals and wildlife could carry the HEV strains able to infect humans. The researchers also identified a need to consider other ways the virus could reach a new human host in New Zealand such as blood transfusions, infected food handlers, inadequately treated drinking water and contact with lakes or streams. The work has prompted a review of how HEV infections are identified and reported in New Zealand, with more research needed to identify the important transmission routes.

FOODBORNE EXPOSURE TO LEAD

Another project undertaken by ESR food chemists for the Ministry for Primary Industries was estimating the exposure to lead by New Zealanders who consume food from lead-shot animals. Lead-based ammunition is used by some New Zealand recreational hunters to hunt wild mammals and birds, although there are restrictions over its use for hunting game birds around waterways. Lead-based ammunition can also be used by home-kill operators or people killing animals for their own consumption. The ammunition expands during its passage through an animal to increase the chance of an immediate kill. At the same time, the lead also fragments, spreading lead particles around the wound channel. These particles are not always visible to someone preparing a carcass for eating, and the presence of lead from the ammunition may present a health risk. There is no safe level of exposure to lead. ESR reviewed available information from New Zealand and other countries, identifying important data gaps and proposing a research path to support future risk management considerations.



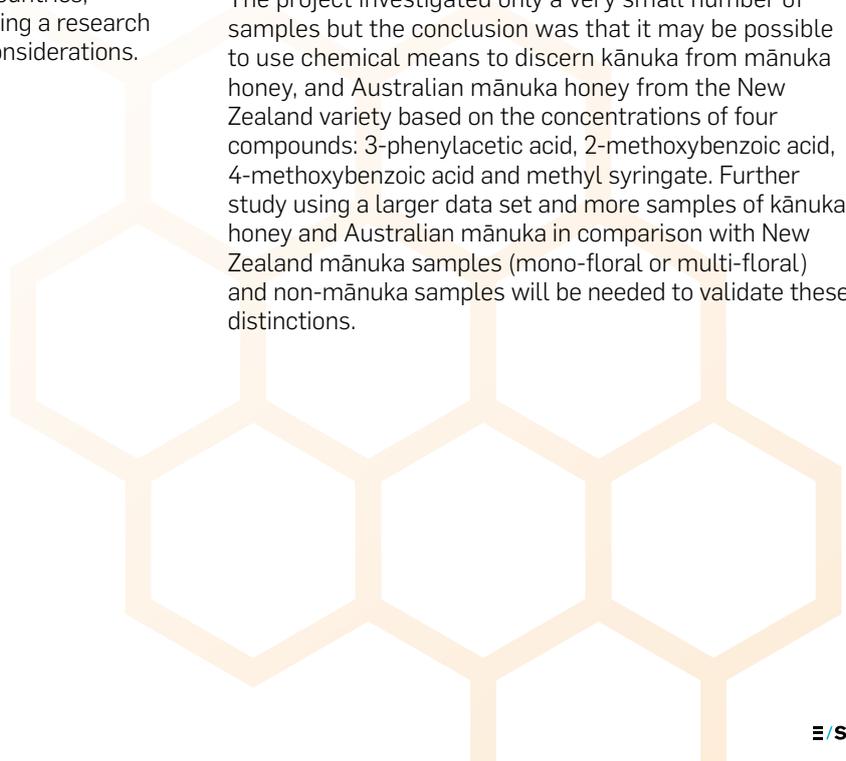
ALL THAT GLITTERS IS NOT GOLD



New Zealand is the world's third-largest honey exporter with mānuka honey sales fuelling a large portion of growth. Honey has long been known to have antimicrobial properties, with a small number of honey varieties having enhanced antibacterial activity beyond normal honeys. Mānuka honey, produced from the *Leptospermum scoparium* native New Zealand species (known by its Māori name, mānuka), is one such variety. As a valuable commodity, mānuka honey is prone to adulteration and the sale of fake mānuka honey is rife around the world.

ESR's analytical food chemists went on a search to find potential chemical markers that would enable the authentication and differentiation of mānuka honey from other varieties in order to reassure overseas regulators and consumers who desired a government-backed definition to safeguard the authenticity of mānuka products. This would also ensure the effort to differentiate between pure mānuka honey (derived from *L. scoparium*) and blended mānuka honey, non-mānuka honey, kānuka and Australian 'mānuka' honeys (derived from various species in the genus *Leptospermum*) which do not have the superior antimicrobial properties of the New Zealand species.

The project investigated only a very small number of samples but the conclusion was that it may be possible to use chemical means to discern kānuka from mānuka honey, and Australian mānuka honey from the New Zealand variety based on the concentrations of four compounds: 3-phenylacetic acid, 2-methoxybenzoic acid, 4-methoxybenzoic acid and methyl syringate. Further study using a larger data set and more samples of kānuka honey and Australian mānuka in comparison with New Zealand mānuka samples (mono-floral or multi-floral) and non-mānuka samples will be needed to validate these distinctions.



TESTING NEW ZEALAND SHELLFISH TO SEE IF THEY GLOW



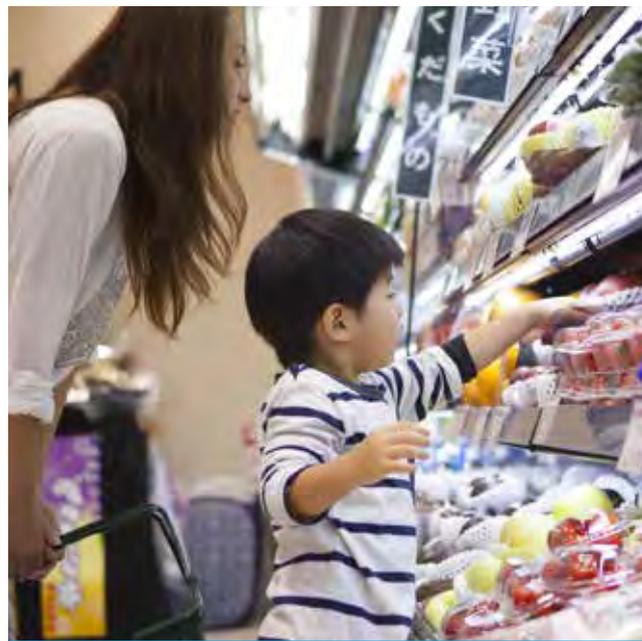
Exposure of the New Zealand population to radionuclides stems mostly from ingesting naturally occurring radionuclides, with polonium-210 (^{210}Po) from eating shellfish providing an appreciable contribution. The concentrations of ^{210}Po in New Zealand shellfish range from 3 Bq.kg^{-1} to 280 Bq.kg^{-1} (wet weight) depending on location and time of year. There is currently only limited information on why these temporal and spatial variations occur. To address this, ESR is investigating the variability of ^{210}Po activity concentration in these important food products.

DETECTING LISTERIA IN SEAFOOD

For ready-to-eat (RTE) seafood, a key microbiological hazard is *Listeria monocytogenes*, a bacterium that can cause listeriosis, a potentially serious disease in susceptible individuals. Seafood is a high-value product with a short shelf-life and is an important revenue earner for our export industry. To meet export quality requirements, RTE seafood must be clear of *L. monocytogenes*, but current testing takes several days to get a result. A rapid test that can detect this bacterium on site would be of great use to the seafood industry by speeding clearance of this perishable product.

ESR scientists, partnering with AuramerBio, a start-up company in which ESR has an interest, used innovative Pioneer seed funding to develop a proof of concept for an aptamer-based assay to detect *Listeria* quickly and on site. ESR has confirmed that, with refinements, this aptamer-based technology could be incorporated into a small sensor device for use in seafood-processing plants, thus adding value to this important sector for New Zealand.

UNDERSTANDING CONSUMER EXPECTATIONS ABOUT FOOD PACKAGING



New food packaging technologies have the potential to provide safer higher-quality foods, extending shelf-life through such things as measuring time and temperature, absorbing compounds that promote spoilage, excreting antimicrobial compounds and providing traceability information such as the origin and composition of the food. The New Zealand food industry is showing increasing interest in using smart packaging technologies to enhance and differentiate their products. In a project led by the University of Otago, ESR is participating in research to determine whether consumers in China see benefits in smart packaging technologies for foods and whether there is a willingness to accept and pay for these new technologies. Customer perceptions regarding the packaging attributes, both positive and negative, will be analysed, providing guidance to the industry to ensure new products meet Chinese consumer expectations.

ENDOLYSINS FOR ONE HEALTH

Globalisation of economies has facilitated a rapid spread of people, animals, plants and agricultural products across the world, which has contributed to increased outbreaks of zoonotic disease. To address this issue, innovative ways of thinking about health from an integrated perspective that involves human, animal and environmental factors are required (a One Health approach). In this project, we are developing new technologies for reducing the burden of zoonotic diseases. This includes a partnership with the University of Canterbury Biomolecular Interaction Centre to develop novel enzymes (endolysins) capable of killing pathogenic bacteria and working with the Queensland Department of Agriculture and Fisheries to develop biocontrol agents to reduce the concentration of *Campylobacter* in poultry.

MEASURING RADIOACTIVITY IN FOOD

ESR's National Centre for Radiation Science (NCRS) regularly tests samples of food for both the domestic and export markets. This year, over 1,000 products were tested and 831 radiological certificates were issued clearing food stuffs, especially milk powder, for export.

The NCRS plays a critical part in the safety of food systems with routine food assessments allowing safe consumption.

It also maintains its readiness to respond to emergency radiological contamination events.



FOCUS ON A MID-CAREER SCIENTIST

SARAH MOLYNEUX



Sarah Molyneux gained a BSc (Hons) at Lincoln University majoring in biochemistry and plant science. She then went on to complete a PhD in clinical chemistry at the University of Canterbury in 2006. Her PhD was supported by Canterbury Health Laboratories, where she set up a method to measure the coenzyme Q₁₀ content of human blood plasma and then carried out human clinical trials involving coenzyme Q₁₀. She was subsequently awarded a National Heart Foundation Research Fellowship to continue this work. In total her PhD and research fellowship research led to the publication of 14 journal articles.

Sarah joined ESR's food chemistry laboratory at the Christchurch Science Centre in 2016. In this team, she conducts routine testing for toxins, preservatives and allergens in food on behalf of the Ministry for Primary Industries, District Health Boards and commercial clients. Sarah also conducts food forensics investigations and she finds this work, with its varied nature, both interesting and challenging.

Another service the food chemistry laboratory provides is the standardisation of portable meters used to determine the free-available chlorine (FAC) in drinking water, which is mandated in the standards. Biannually, District Health Boards and Public Health Units (and some commercial clients and councils) throughout New Zealand send in their FAC meters to be standardised. Precise knowledge of FAC concentration in drinking water that has been identified as a risk is paramount to the health of New Zealanders. Too high FAC can affect the aesthetics of drinking water unnecessarily and can be a health concern whereas too low FAC will not guarantee water is safe for consumption.

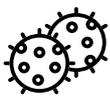




PUBLIC HEALTH

SAFEGUARDING HUMAN HEALTH

SAFEGUARDING THE HEALTH OF NEW ZEALANDERS THROUGH IMPROVEMENTS IN THE MANAGEMENT OF BIOSECURITY AND THREATS TO PUBLIC HEALTH.



3,408

superbugs tested in AMR collection



20,597

notifiable diseases reported



627

disease outbreaks tracked

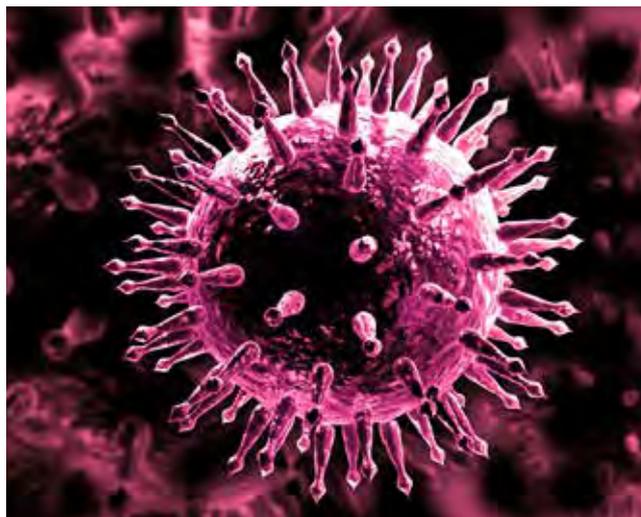


42

medicines tested for counterfeit or adulterated products

ESR provides essential services in the area of public health contributing to the health and wellbeing of New Zealand communities. We are at the forefront of protecting New Zealanders against known and emerging diseases.

Our team of health scientists, medical practitioners and clinicians provide extensive disease surveillance services, scientific research and clinical expertise to help prevent and reduce disease, especially in the area of communicable and infectious disease. Our nationally and internationally accredited microbiological public health reference laboratories operate within global networks to detect, identify and classify disease-causing organisms using both classical culturing techniques and the latest advancements in whole genomic sequencing. Our scientists and epidemiologists analyse information and notifiable disease data to create intelligence for our clients. Our social scientists apply their knowledge and expertise to highly complex issues developing evidence-based, logical and workable conclusions that others can rely on to inform their future decisions.



COMBATING INFLUENZA

ESR monitors influenza trends, provides intelligence to the health sector, and addresses critical questions regarding the virology, epidemiology and immunology of influenza and other respiratory viruses.

We operate a national surveillance system to provide timely and comprehensive intelligence on respiratory virus activity and severity in New Zealand. In addition to tracking cases of acute respiratory illnesses and influenza, ESR's public health experts characterise respiratory viruses and viral strains and assess the effectiveness of influenza control measures. This information helps the health sector manage influenza each season.

TRACKING INFLUENZA



Building on improvements to the real-time collection of influenza-like illnesses implemented last year is an internet-based influenza intelligence dashboard.

This new one-stop shop provides, on a near real-time basis, a measure of the impact of influenza during the season. This includes information on current activity and severity and which influenza viruses are circulating in the season along with demographic information and a breakdown of influenza by District Health Boards. This information is gathered as part of the national influenza surveillance programme from a range of sources including laboratories, intensive care units, emergency departments, GPs and Healthline. While it is aimed at health professionals, it also provides a guide to members of the public who want to find out how flu is tracking through the season.

WATCHING OVER INFECTIOUS DISEASES



If there is one thing that can help New Zealanders sleep at night, it is knowing that ESR is keeping watch over a wide range of infectious diseases.

Our nationwide public health surveillance system involves collecting, collating, analysing, and interpreting data from a wide range of sources including laboratories, GPs, emergency departments and even social media to provide the health sector with intelligence to support its response to public health threats.

ESR supports Public Health Units in their outbreak investigation activities. This year, ESR has provided support during national outbreaks of mumps and whooping cough and a number of smaller outbreaks including paratyphoid in Hawke's Bay and measles in Queenstown. The work is appreciated by the health sector, with ESR's work given high praise by one Medical Officer of Health who commented that "ESR's work was exemplary".

Along with the extensive intelligence reporting published on the Public Health Surveillance website (www.surv.esr.cri.nz/index.php), the Health Intelligence Group supports New Zealand's national security system, providing intelligence on domestic and international emerging health threats and reporting to the Ministry of Health on an on-going basis.

The ESR Health Intelligence Group and Informatics team undertook Coordinated Incident Management System (CIMS) training and emergency response training at the National Health Coordination Centre (NHCC) – the Ministry of Health emergency operations centre that operates during nationally led responses to a broad range of health threats such as pandemics or earthquakes. It is expected that ESR's teams will play an important role in the Ministry's response to any such threat, based either at the NHCC or the National Crisis Management Centre in the bunker at the Beehive.

ESR was also part of the Ministry of Health-led team that supported New Zealand's successful application to the World Health Organization's Regional Verification Committee (RVC) for recognition of measles and rubella elimination with the RVC stating "The RVC verifies that New Zealand has achieved the interruption of endemic measles and rubella virus transmission for a period of at least 36 months in the presence of high-quality surveillance and supporting genotype evidence, and congratulates the country for this achievement."

FIGHTING RESISTANCE TO ANTIMICROBIAL DRUGS



Antimicrobial resistance is a major issue worldwide. The cost to individuals and society as microorganisms (bacteria, viruses, parasites or fungi) become resistant to drugs could be enormous with common infections becoming untreatable and normal medical procedures life threatening.

Each year, ESR undertakes extensive surveillance that contributes towards efforts to combat antimicrobial resistance to human pathogens. ESR collates the antimicrobial testing results from diagnostic laboratories throughout New Zealand to estimate national rates of resistance and monitor changes. Although rates of antimicrobial resistance are relatively low in New Zealand, they are on the increase. While new types of resistance often emerge in overseas countries, they eventually make their way to New Zealand. Overuse of antibiotics is a major driver of resistance both internationally and in New Zealand. ESR closely monitors antibiotic consumption in the community, using prescription data.

The seminal report, produced by ESR, *Antibiotic Consumption in New Zealand 2006 – 2014*, found that New Zealand has high rates of antibiotic consumption compared with many other countries and that consumption significantly increased during that period. A call was made by the health sector to educate the medical community on appropriate antibiotic prescribing.

In 2017, ESR was on the team that produced the *Antimicrobial Resistance Action Plan*, jointly led by the Ministry of Health and the Ministry for Primary Industries. As part of the plan, ESR has taken responsibility for work relating to strengthening the knowledge and evidence base about antimicrobial resistance through surveillance and research. A national Antimicrobial Susceptibility Testing Committee has been established to ensure consistency of testing in all laboratories across New Zealand so that resistance data is comparable.



ESR undertakes further extensive antimicrobial susceptibility testing and specialist testing to determine the genetic basis of resistance. Current research is looking at the carbapenemase-producing bacteria: Enterobacteriaceae (CPE). These bacteria are resistant to nearly all antibiotics and include common bacteria such as *Escherichia coli* and *Klebsiella pneumoniae*. In New Zealand, the incidence of CPE has increased from three isolates in 2012 to 48 in 2017. In 2017, ESR conducted whole genome sequencing in parallel to traditional laboratory testing to provide additional information including identifying new carbapenemase genes and the genetic relationship among isolates to inform outbreak investigations. Carbapenemase genes are carried on plasmids (extra-chromosomal circular DNA commonly found in bacteria) that can easily spread between bacterial isolates. Some plasmids are more easily transferred between bacteria than others, so it is important to know what type of plasmid is carrying the carbapenemase gene. In addition to short read-based whole genome sequencing, we have also used the portable DNA sequencer, the Oxford MinION, which can sequence large strands of DNA to characterise plasmids carrying antimicrobial resistance genes.

EMBRACING THE GENOMICS REVOLUTION



Genomics is the characterisation and quantification of genetic material in an organism, made possible by sequencing the complete list of the nucleotides that make up a species. DNA sequencing generates detailed data about these basic building blocks of life. Bioinformaticians use their knowledge of biology, computer science, mathematics and statistics to collect, analyse and interpret these genomes to enable scientists to understand disease.

ESR has embraced this fast-moving field of genomics and increased its genomics and bioinformatics expertise and capability in the application to microbiology, human forensics and human non-communicable diseases. Whole genome sequencing is rapidly replacing traditional molecular typing methods for the characterisation of microbial pathogens as it is more informative than current methods for public health investigations of infectious diseases. This year, the organisation increased its sequencing capacity by acquiring sample automation instruments to supplement the MiSeq and NextSeq550 DNA sequencing and cytogenomic microarray instruments. The new DNA robot automates DNA extraction from samples, and the fragment analyser performs the quality control check in sample preparation. We also regularly use the Oxford Nanopore MinION, which provides real-time data analysis while the sequencing is occurring, especially in situations where response time is critical and the rapid availability of results is crucial.



Genomic sequencing is now being used to track and identify sources of high-risk pathogens and local disease outbreaks with public health implications. We will continue to develop our scientific capability to sequence microbial pathogens, and establish and maintain a baseline library of New Zealand genomic sequences of human pathogens. This year, we have sequenced the whole genome of a number of bacteria including *Neisseria meningitidis*, *Salmonella enterica*, *Listeria monocytogenes* and Shiga-toxin producing *Escherichia coli*. This allows us to better compare cases and provide greater assistance with outbreak investigations.

TEN YEARS OF PROTECTING NEW ZEALAND FROM BIOSECURITY THREATS



ESR celebrated the 10th anniversary of the opening of the National Centre for Biosecurity and Infectious Disease (NCBID) at Wallaceville, near Upper Hutt. NCBID, which opened in May 2008, cemented ESR’s role in providing critical scientific services for human biosecurity control. It brought together ESR’s National Influenza Centre and four of ESR’s communicable disease laboratories: Enteric Reference Laboratory, Leptospira Reference Laboratory, Virus Identification Reference Laboratory and Arbovirus Laboratory. It also enhanced surveillance, outbreak investigations and epidemiological resources on the site. The opening of NCBID was very timely. Just the following year, the H1N1 influenza pandemic (swine flu) was being felt across the world, and the staff expertise and facilities at NCBID were pivotal to New Zealand’s ability to respond to the pandemic. ESR’s National Influenza Centre scientific staff were joined by staff from MAF and AgResearch in the pandemic response, realising the NCBID’s original vision of providing a comprehensive scientific coordination and emergency response to emerging biosecurity threats. Since then, NCBID has been a centre for virology research such as the SHIVERS work. It has also developed outbreak investigation services, and training courses for public health staff have been going for the best part of 10 years with many alumni now in position around the country.

NEW ZEALAND MICROBIOLOGY NETWORK

ESR coordinates and administers the New Zealand Microbiology Network, a network of clinical microbiologists around the country with links to a similar organisation in Australia. The network is approximately four years old and is working very effectively to coordinate and enhance the testing of microbiological organisms in New Zealand and improve our preparedness to emerging infections.

FOCUSING ON OUR EMERGING SCIENTISTS

NAMRATA PRASAD



Namrata Prasad is a young and promising virology researcher, who is studying for her PhD through the University of Auckland by working at ESR as part of the SHIVERS team. She is funded through a Pacific Health Research Council PhD Scholarship.

Namrata led a study entitled “Interactive effects of age and respiratory virus on severe lower respiratory infection”, which was accepted for publication by *Epidemiology and Infection* journal in June 2018. This study was the first of its kind to examine the age of the child and the risk of severe acute lower respiratory infections among hospitalised children under two years old.

The findings suggest that to control severe acute respiratory infections in these children, respiratory syncytial virus specific interventions (such as supplemental oxygen, mechanical ventilation, and fluid replacement) would benefit those aged under six months while influenza vaccination and antiviral treatments would be used more to reduce influenza-associated severe outcomes in children aged between six and 24 months. This information will be useful in the management of influenza in young children.





WATER AND THE ENVIRONMENT

KEEPING WATER CLEAN

IMPROVING
THE SAFETY
OF FRESHWATER
AND GROUNDWATER
RESOURCES FOR HUMAN
USE AND THE SAFER USE
OF BIOWASTE.



4,736

faecal source tracking tests to identify water contamination



29

wells supplied data for analysis of groundwater denitrification



643

soil samples processed



10

collaborators in the ESR-led Centre for Integrated Biowaste Research projects

Safe water is fundamental to a healthy New Zealand society. ESR works to improve the safety of water that we drink, use and play in and advise on the safe reuse and disposal of wastewater.

We provide scientific advice and expertise on the management of surface, drinking, ground, recreational and wastewater and biowaste to health authorities, local and central government, industry and communities. Our work includes the surveillance and reporting of drinking-water quality, scientific advice on health and environment public policy, research on water-quality issues relating to drinking water and recreational waters and information systems management.

ESR is also a valued advisor in the Pacific Islands, supporting local communities and government with water quality, sanitation and hygiene advice to improve water standards in the region. We lead the Centre for Integrated Biowaste Research, a collaborative multi-disciplinary programme delivering innovative solutions for the sustainable reuse of biowaste.

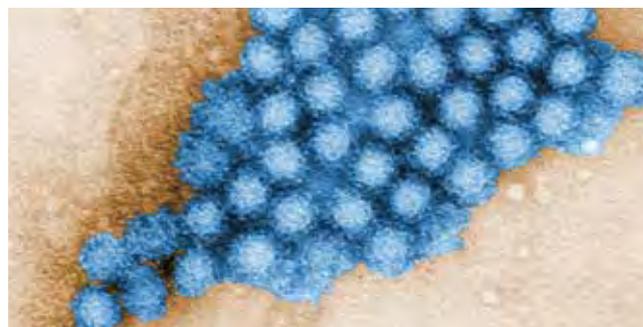


DRINKING-WATER SUPPLY AND QUALITY

With backgrounds in public health, microbiology, environmental radioactivity and chemistry, our scientists help clients understand the quality of their drinking water and the implications of that quality for water treatment.

Each year, ESR compiles the *Annual Report on Drinking-water Quality* for the Ministry of Health. This year, analysis showed that 96.2% of the report's population (registered networked drinking-water suppliers serving over 100 people) met the bacteriological standards for water quality. To meet the overall requirements of the standards, a supply must meet the bacteriological, protozoal and chemical standards. Overall, 81.1% of New Zealanders (3,094,000 people) received drinking-water that met all requirements of the standards in 2017. This represents a 1.1 percentage point improvement compared with 2016.

NEW TECHNOLOGY TESTS WATER FILTRATION SYSTEMS



Water suppliers will benefit from new ESR technology that tests the efficiency of filtration systems commonly used in community water supplies and domestic point-of-use filters. ESR scientists have developed tiny biomolecule-modified surrogates for disease-causing organisms, *Cryptosporidium*, rotavirus, adenovirus, and norovirus. These harmless and inexpensive surrogates are tagged with DNA markers or dye to see if they are being removed by the filtering process. International studies have shown that some organisms can break through the treatment filters. Current tools for assessing the effectiveness of microbial removal of water treatment are quite limited. The study has been running a pilot plant, installed at Invercargill's Branxholme Water Treatment Plant for the last 16 months. The surrogate technology is also being demonstrated in actual settings such as pilot-scale sand filters and domestic point-of-use filters. The potential is there for the surrogates to test the performance of filtration systems, helping to ensure the safety of community drinking-water supplies.

NATIVE PLANT SPECIES ENLISTED TO HELP CLEAN UP WATERWAYS



The antimicrobial properties of a range of New Zealand native plants are being studied for their ability to reduce bacterial counts and nitrate levels in soils. Previous research has shown that the root system of mānuka trees has the ability to remove pathogens and nitrates from the ground. In greenhouse-based tests, *E. coli* died off much faster in soils under mānuka than under pasture, and significantly reduced the leaching of nitrate compared with both pasture and pine trees. The ESR-led Centre for Integrated Biowaste Research is now looking at the potential of rātā and horopito to see if they have similar properties. Rātā, horopito and mānuka seedlings, irrigated with dairy shed effluent, are being tested to see if *E. coli* is removed faster by these plants. We already have mānuka planted in field trials to see if it can reduce *E. coli* from leaching into waterways in a farm catchment. The big potential of the study is to identify other plants that work as well as or even better than mānuka. The results of this research would be to have better biodiversity in riparian plantings, especially in farm catchments.



RESTORING THE HEALTH AND WELLBEING OF THE LAKE AND WHĀNAU OF MATAHURU



At one time, Lake Waikare in Lower Waikato was a source of sustenance for the whānau of Matahuru. In recent years, the health and wellbeing of the lake and surrounding catchment have been degraded by high inputs of nutrients, sediments, algae and bacteria from farm run-off, and removal of the vegetation-filtering potential around lake margins.

The lake has been the focus of a number of vegetation restoration projects led by Waikato Regional Council, local iwi and the Waikato River Authority. This included the planting of 50,000 mānuka trees around the lake over the last year. However, the benefits of this restoration in accordance with kaitiakitanga have never been evaluated.

The strategic importance of Lake Waikare and the Whangamarino Wetland as the lungs and kidneys for the lower Waikato is recognised by local iwi. These areas have multiple cultural, ecological, recreational and economic values. The degradation of the lake impacts on the spiritual and social connections of the mana whenua of the lake.

ESR, as part of the Centre for Integrated Biowaste Research is working with Ngā Muka Development Trust, Te Riu o Waikato Limited, Matahuru Marae/Nikau Whānau Farm Trust and Waikato Regional Council to create a monitoring system that will join western science with mātauranga Māori and taiao values. The monitoring system will measure the benefits of riparian vegetation restoration on the health and wellbeing of the lake and whānau of Matahuru. The system will provide a map or pathway to measure the progress of the return of the lake to the modern-day equivalent of the environmental state that it was in when Kīngi Tāwhiao composed his maimai aroha, including waters that are drinkable, swimmable and fishable, as stated in the Waikato-Tainui Environmental Plan.

To develop the monitoring system, a multi-generational approach is being taken that explores iwi tūpuna connections and relationships with the lake. Linking this mātauranga with western science enables a map to be developed that identifies ecological, socio-cultural and spiritual indicators for the assessment of the success of restoration plots.

VIRUS REMOVAL IN WASTEWATER

The Virus Removal in Wastewater project is an ESR-led research group that aims to advance knowledge of the efficiency and relative importance of processes involved in virus removal in natural wastewater systems such as oxidation ponds.

The research has grown from a project aimed at optimising virus removal in wastewater systems through a sustainable and low-cost approach. The current project expands on that research, focusing on enhancing the understanding of the complex mechanisms existing in wastewater that have the potential for virus (and other microbial pathogens) removal. In particular, the research is focused on those mechanisms that act independently of light – the main driver of natural virus removal.

The behaviour of wastewater-associated viruses and other pathogens in the absence of sunlight is not fully understood. By advancing understanding of 'dark' removal mechanisms, opportunities for optimising pathogen removal can be evaluated.

Other removal mechanisms such as the sedimentation of particle-associated pathogens will vary depending on the properties of microbes (viruses in particular) – variants such as surface characteristics, size and mobility of the microbe in question. Experiments are currently being conducted to extend knowledge of the attachment and/or aggregation and settlement behaviour of a range of viruses and other pathogens in wastewater.

HOW CLIMATE CHANGE WILL IMPACT ON HEALTH



ESR was commissioned by the Ministry of Health to produce a report showing how climate change could impact New Zealanders' health. The report entitled *Climate Change and Environmental Health*, was released in late May 2018 and anticipates future environmental health risks in New Zealand over the next 50–100 years so that plans can be put in place to understand what these effects are, where they might be most felt, who will be most vulnerable to them and ways to mitigate or adapt to the effects.

ESR undertook a review of the scientific literature relating to climate change and environmental health, summarising national and international understanding of these likely effects and identifying gaps in this understanding. The work provides information that can be used as a basis for deciding the next steps needed.

It sets out the problems that could occur including increased allergens and irritants in the air, extreme weather events, ultra-violet solar radiation and increased vector-borne, waterborne and infectious diseases. The spread of infectious disease, particularly in New Zealand's water sources, was noted as being of concern and needing greater attention.

Associate Minister of Health Hon Julie Anne Genter said upon the release of the report that the climate is changing and how it impacts on people's health will also change. She said that the health system needs to be better prepared to deal with increased temperatures and more extreme weather events.

DENITRIFICATION WALL COULD SOLVE SILVERSTREAM'S NITRATE WOES



ESR's pilot study for a denitrification wall at Silverstream Reserve near Kaiapoi could lower the stream's high nitrate levels. A project assessing whether this method, which has successfully been used with sandy aquifer systems in the Waikato and the USA, could have the same results for the fast flowing heterogeneous gravel aquifer systems like those in Silverstream and elsewhere in Canterbury. The denitrification wall operates as a groundwater filter. A wall constructed of woodchip mixed with gravel aggregate strips nitrate from any groundwater passing through the wall. Carbon material within the wall provides a food source for bacteria in the ground to convert nitrate in groundwater passing through the wall to a harmless di-nitrogen gas (N₂) – 80% of the air we breathe. The pilot project would be a world-first as denitrification walls have not previously been tested in gravel aquifer systems. If the results from the pilot study show the denitrification wall is able to remove nitrate from groundwater up-gradient of Silverstream and improve water quality, it would be a good result for the local community.



GROUNDWATER INDEX

ESR is collaborating with the University of Auckland to get a better understanding of the natural microbial character of groundwater and mechanisms that promote beneficial groundwater nutrient conditions.

With a better understanding of aquifer biology, there can be improved management of groundwater quality and ultimately, higher-quality groundwater for New Zealand.

FOCUS ON OUR EMERGING SCIENTISTS

ANNABELLE THAM



Annabelle Tham is a University of Otago PhD student in ESR's Environmental Science department. She is working on a Health Research Council project, studying virus and protozoan removal in drinking-water filtration processes using pathogens and micro-mimics under the supervision of Dr Liping Pang and Professor Vernon Ward. She has a Diploma in Biomedical Science from Singapore Polytechnic, and a Bachelor of Biomedical Science (Hons) from the University of Queensland, where she specialised in immunology and infectious disease studying the role of microRNAs in virus infection in the common fruitfly, *Drosophila melanogaster*.

Her PhD project aims to investigate microbial removal efficiencies of drinking-water filtration systems using pathogens and biomolecule-modified particles that mimic the physical and chemical properties of the respective waterborne pathogens. This is partially achieved by testing a previously validated surrogate in real-world scenarios at a pilot plant at Invercargill's Branxholme drinking-water treatment plant. Here, protozoan removal was tested using micro mimics of *Cryptosporidium parvum* oocysts through a number of different filter media commonly used in these plants.

More than 45 individual trials were conducted, not including time-series experiments that investigated the effect of backwashing and filter ripening on the removal efficiencies of the media, and data collected include influent and effluent concentrations of the surrogates and real-time turbidity measurements. It was found that out of three filter media configurations, Aqualite™ – an engineered ceramic media, was the most efficient filter media in removing protozoan mimics. The next part of her project will be investigating the removal of viruses and their respective surrogates at ESR using a pressurised system, specially built for this project, to test domestic point-of-use filter cartridges.

By demonstrating the efficiencies and limitations of each filter type or filter media, the results of this study will be used to make recommendations to city councils, water providers of networked supply, and manufacturers of filtration devices so that preventive measures can be taken to reduce waterborne disease outbreaks. Armed with the knowledge of their system's capabilities in removing pathogens, water suppliers will be able to improve their water safety practices. Consumers will also have a better understanding of domestic filters available and be able to make informed decisions when choosing a system.

WORKING IN THE PACIFIC

ESR assists the Pacific region with scientific expertise, information and tools to strengthen policy, programmes and practice to achieve healthy, safe and resilient communities.

ESR's focus in the Pacific is aligned with the New Zealand Aid Programme's strategic plan and sector priorities, particularly providing scientific support to several of the enablers of sustainable economic development (health, water supply and sanitation). We work in partnership with regional organisations such as the Secretariat of the Pacific Community (SPC), the World Health Organization (WHO), UNICEF, Pacific governments, not-for-profit organisations, and New Zealand CRIs and universities.

PLANNING FOR THE IMPACTS OF CLIMATE CHANGE

Pacific island countries are starting to think about preparing country-level Climate Change and Health Action Plans (CCHAPs) as an integral part of their country's Joint National Action Plan for climate change adaptation and disaster risk management (JNAP). Such plans respond to the urgent need to anticipate, prepare for and respond to the increasing instances and impacts of natural disasters and climate change events those countries are experiencing. The goal is to assist country-level CCHAP development as an integral part of the JNAPs development. The impact of this for Pacific island countries will be an increased resilience of communities to the health threats posed by climate change and natural disasters. ESR has developed a health adaptation and action plan for climate change and disaster risks in Pacific island countries, a tool that will assist the integration of CCHAPs and JNAPs. Tonga's Ministry of Health has asked ESR to assist it in developing their CCHAP. Piloting of the tool in Tonga will help us to ensure the tool is practical and can be used subsequently by other Pacific island countries. ESR is also in discussion with the Secretariat of the Pacific Regional Environment Programme on climate change and other priority areas of mutual interest.

RESEARCHING CORAL SAND



ESR has been researching the microbial removal properties of coral sand found in Kiribati for the past six years. Our research has so far focused on using coral beach sand, sourced from the atoll of South Tarawa in Kiribati, as a porous media for the treatment of household domestic effluent. The results have been promising in a laboratory setting, but further investigation is required in the field to verify the results. This research has been conducted by one of ESR's groundwater scientists, Bronwyn Humphries, through her master's thesis with the University of Canterbury. Bacterial and viral indicators (*E. coli* J6-2, *E. faecalis* and MS2 phage) along with viral pathogens (adenovirus, echovirus, norovirus and rotavirus) were drained under gravity through coral sand-packed

columns, serving as physical models of a domestic effluent drainage field. The results show that coral sand has a higher affinity for attenuating viruses than bacteria. All organisms examined showed removal efficiencies over 4-log removal values (LRVs), which is equivalent to a 99.99% reduction in the target microorganisms. Attenuation mechanisms such as absorption and to a lesser extent physical straining likely play a major role in the ability of coral sand to attenuate the microbial tracers used in this study. Long-term field-scale studies are required to verify the laboratory results as well as incorporate the effects of king tide events, fluctuations in groundwater, effects of prolonged rainfall and examining microbial transport within coral sand under saturated conditions. These findings can have important implications for the use of locally available natural materials in Kiribati, such as coral sand, to improve household on-site wastewater treatment and potentially drinking-water treatment by the use of household sand filters. This research is contributing to developing sustainable innovative wastewater and water treatment technologies within the Pacific, which is a great result for these vulnerable environments and also for health outcomes of people.

RADIATION SAFETY AND SECURITY IN THE PACIFIC

Over the last few years, the ESR Radiation team from the National Centre for Radiation Science has been working in partnership with the International Atomic Energy Agency (IAEA) and the New Zealand Ministry of Foreign Affairs and Trade to assist Pacific island countries in developing an infrastructure to improve the safety and security of radioactive material in the region. ESR has hosted a number of workshops in New Zealand and provided experts to IAEA missions in the Pacific. The aim has been to raise the awareness of the safe and secure use, storage and transport of radioactive material and to provide the technical support and tools to enable Pacific island countries to develop national inventories of radioactive materials and set up rudimentary regulatory controls and emergency response capability. As a result, a regional network has been established and action plans have been developed at regional and national levels. There is much work to be done to raise the radiation safety and security infrastructure to a reasonable standard, and ESR expects to provide mentorship and technical support in the coming years. IAEA has recently engaged ESR to procure and supply radiation-monitoring instruments to some of the countries in the region. This will enable those countries to perform radiation safety inspections and assessments. Importantly, this will also give those countries the ability to respond more effectively in the event of radiation incidents and accidents.



OUR SCIENCE AND RESEARCH



ESR uses the power of science to protect and enhance the nation's health and wellbeing by addressing challenges that require science-based innovations in health and disease, justice and security, food safety, the health of the environment and the quality of freshwater.

OUR SCIENCE

ESR uses the power of science to protect and enhance the nation's health and wellbeing by addressing challenges that require science-based innovations in health and disease, justice and security, food safety, the health of the environment and the quality of freshwater.

We make a difference to New Zealand through delivering independent, expert scientific advice and services, providing clients with better data, evidence and analysis to support the decisions that safeguard people's health, protect our food-based economy, improve the safety of our water and ensure justice is served.

Our nationally and internationally recognised team of scientists, technicians and clinicians span the disciplines of microbiology, analytical chemistry, virology, toxicology, epidemiology, forensic biology, bioinformatics, data science, and social, radiation and environmental sciences.

We work with a network of other science and research institutions contributing to scientific advancements and collaborating with our strategic partners to help deliver better outcomes for New Zealand and globally. These include other Crown Research Institutes, independent research groups, universities, government agencies and local authorities as well as international scientific bodies.

Our science innovations are driven by the need to apply our science to better deliver services for our clients. We adapt new science to New Zealand conditions. We also develop and utilise innovative ideas, techniques and technologies that underpin our science, harnessing new technologies such as genomics, bioinformatics and data science to solve the complex problems of today.

GROWING OUR RESEARCH

To enable us to increase our scientific research and capability, ESR actively seeks and obtains funding from government and non-government sources. This includes funding from the Ministry of Business, Innovation and Employment (MBIE) Strategic Science Investment Fund (SSIF), Royal Society Te Apārangi Marsden Fund, Health Research Council, MBIE Endeavour Fund, KiwiNet, and local government. Internationally, funding comes from private companies and research organisations such as GlaxoSmithKline, National Institutes of Health (US) and St. Jude Children's Research Hospital. Research revenues increased 20% in 2018, with international contracts building on ESR's expertise and reputation. ESR has also been successful with several MBIE Vision Mātauranga research funding applications, representing tangible progress towards ESR's objective of prioritising Vision Mātauranga research to the benefit of Māori and New Zealand.

Our science innovations are driven by the need to apply our science to better deliver services for our clients



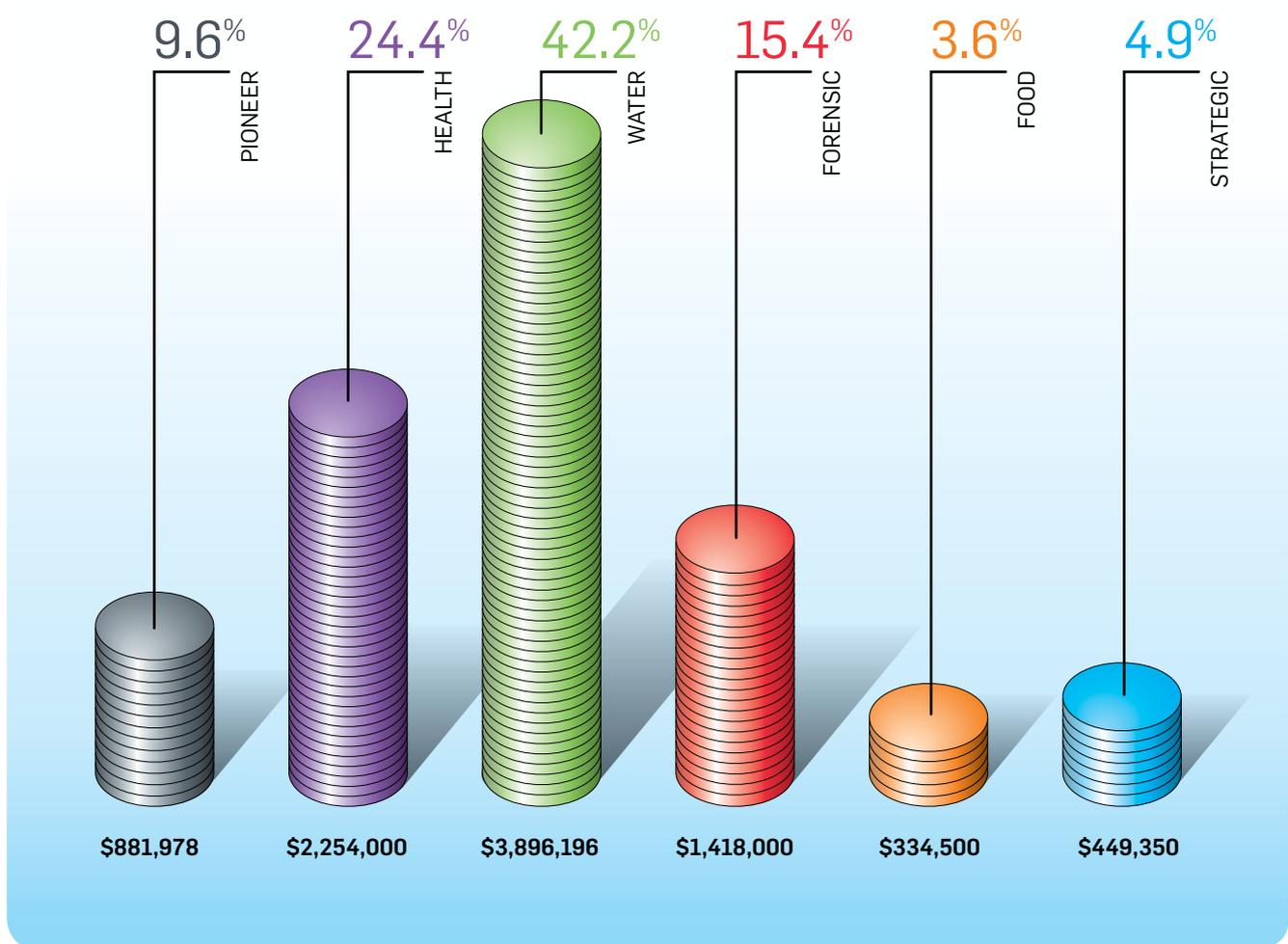
STRATEGIC SCIENCE INVESTMENT FUND

To support our core research platforms of human and environmental health and forensic science, ESR received \$9.2 million from the Strategic Science Investment Fund in the 2017/18 financial year.

Funds were allocated to ongoing research projects in the genomics and bioinformatics portfolio, National Science Challenge-aligned research, human health, biowaste, groundwater and environmental health. Newly funded research included developing evaluative reporting frameworks, improved surveillance of new psychoactive substances, greywater, endolysins, and new surveillance sources to track the flu.



MBIE STRATEGIC SCIENCE INVESTMENT



GENOMICS AND BIOINFORMATICS RESEARCH



Genomics and bioinformatics have become essential tools in characterising DNA markers at the molecular level and are a large component of ESR's services and research. ESR is actively building its capability in this field to stay at the forefront of delivering state-of-the-art services to our clients and to an internationally comparable standard.

Projects include establishing microbial whole genome sequencing across the business for service delivery, research and other commercial opportunities. This means replacing existing microbial serotyping and genotyping methods with whole genome sequencing, which is now the internationally accepted reference typing method for outbreaks and public health investigations of infectious disease due to its ability to reveal transmission networks and trace infection sources with greater accuracy.

Developing ESR's communicable disease and outbreak investigation toolbox is another project funded by SSIF. This includes new approaches for epidemiological investigation of disease-causing organisms – verotoxinogenic *Escherichia coli* (VTEC), *Clostridium* and *Neisseria* as well as antimicrobial-resistant bacteria.

We have done research into metagenomics including using whole genome sequencing to develop a single test to detect thousands of complex microbe genes in a sample using hand-held technology, specifically the MinION, in field testing.

In the forensics area, scientists are attempting to transform forensic DNA profiling into an approach that is potentially faster, less expensive and more informative and has the ability to generate new intelligence for the justice sector. This involves identifying markers for ancestry, eye colour, and hair that can be used in the absence of a DNA Profile Databank link and from compromised crime scene material.

NATIONAL SCIENCE CHALLENGES

There are a number of SSIF projects aligned with New Zealand National Science Challenges.

Our Land and Water Challenge – modelling transport of nutrients and pathogens in heterogeneous aquifers

This project models and predicts the transport of microbes (nutrients, indicator bacteria, surrogates and nasty bugs) through the groundwater systems with particular emphasis on campylobacteria. Research will also focus on modelling nitrate transport in groundwater and the impact novel denitrification technologies (permeable reactive barriers) have on groundwater.

Exploring collaboration

Another project that falls under the Our Land and Water Challenge explores the role of collaboration in transforming the management of the land and water programme within the challenge. The aim of the project is to improve understanding of what makes for effective collaborative processes for development and implementation of pathways towards achieving water quality limits and other community values. The project researched the practitioners' experience and perspectives of collaboration in Southland, Canterbury and Wellington as well as from a network of experienced collaboration practitioners.

New Zealand's Biological Heritage Challenge – a groundwater health index

This project develops a groundwater health index to understand the shifts in aquifer microbial populations due to man-made activities and identify the key indicator species in such populations that can provide a way to assess the environmental impacts on these underground organisms.

Healthier Lives Challenge – epigenomics for healthcare

Research to identify new biological markers (DNA methylation and non-coding RNA), using obese patient groups with type 2 diabetes and characterising their tissue-specific microbiome, aims to develop methods for use in clinical settings to help with diagnosis and prognosis of disease.

Systems-thinking research, undertaken by our Social Science team, is exploring the ways in which the health sector engages with stakeholders such as schools and workplaces to create supportive environments that actively encourage healthy eating and physical activity. The research focused on the ways in which Healthy Families Christchurch is working with its key stakeholders including schools, Pasifika churches, workplaces, iwi and NGOs and other community settings. The aim of the study was to identify what enables or hinders good engagement and inter-sectoral health action.



GROUND-BREAKING RESEARCH

SHIVERS-II



Building on the success of the previous SHIVERS (Southern Hemisphere Influenza and Vaccine Effectiveness Research and Surveillance) study conducted between 2012 and 2017, ESR has won a contract from the United States National Institute of Allergy and Infectious Diseases, part of the US National Institutes of Health, through the St. Jude Center of Excellence for Influenza Research and Surveillance (SJCEIRS) in Memphis, USA. SHIVERS-II will research people’s immune responses to the influenza infection and influenza vaccinations. The information will help public health officials in both the southern and northern hemispheres regarding the timing and type of influenza vaccinations to recommend. It may also lead to better influenza vaccines in the future. The information is critical for improving seasonal influenza control and pandemic preparedness. It will enable scientists to understand hosts’ immune responses and identify better immune diagnostic markers. This will shed more light on the development of future vaccines such as a universal influenza vaccine. It will make a difference to the way influenza is managed in the future, both in New Zealand and globally.

SHIVERS-RSV



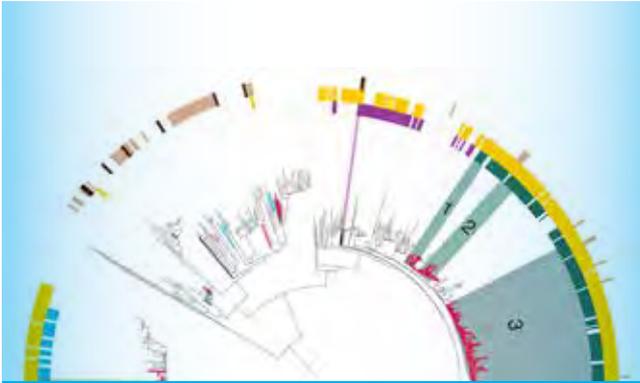
ESR has obtained significant research funding from GlaxoSmithKline for the 2017 and 2018 influenza seasons. This is based on the SHIVERS hospital surveillance platform, the expertise within the team, and the international reputation that the previous SHIVERS study has built. This study will focus on assessing respiratory syncytial virus (RSV) disease burden, epidemiology and economic cost. This information is critically needed because RSV is a leading cause of hospitalisation and mortality in children and the elderly worldwide, and candidate vaccines will be available in the near future.

ESR INFLUENZA STUDY FINDINGS A WORLD FIRST



Work undertaken by ESR, led by ESR Virologist Dr Sue Huang, her team and collaborators, is the first in the world to show a particular and surprising immune response among people to influenza, and could help pave the way to a globally sought universal influenza vaccine. The study was part of the initial SHIVERS research. It looked at 1,500 children and adults who were randomly selected from GP practices in Auckland and significantly changed understanding of a critical part of the influenza virus. The second and less studied of the influenza virus’s two main proteins, neuraminidase, showed a strong immune response particularly among children under five. There was also a response of a similar strength among people infected with influenza B virus. Influenza viruses have two main proteins, and the accepted practice over many years has been to focus on immune responses against the haemagglutinin protein, which is the most common protein found on the influenza virus surface. No previous study has looked at the antibody response to the two proteins from the same person at the same time during natural influenza infections in a population-based serosurvey. Unlike the main protein haemagglutinin, neuraminidase has been a largely ignored component in vaccine development. Comparing antibody responses to the two most abundant proteins of the influenza virus will not only improve understanding of how the body responds to and protects itself against influenza but will also optimise pandemic and seasonal vaccine design, particularly for the development of broad and durable universal vaccines.

EVOLUTION OF A MICROBIAL PATHOGEN



ESR is using whole genome sequencing to analyse and understand a large-scale prolonged meningococcal epidemic that New Zealand experienced between 1991 and 2008.

Infectious disease outbreaks and epidemics are a significant burden on health systems. Understanding what constitutes epidemic potential, how epidemics emerge and their subsequent evolution can inform surveillance and may reduce future epidemics.

As part of a research project funded by the Health Research Council, ESR has a unique opportunity to analyse a meningococcal epidemic in detail. This ESR project – *Evolution of an epidemic: emergence and adaptation of group B meningococci in New Zealand* – is using genome sequencing to investigate the emergence of the epidemic strains as well as its diversification during the epidemic. By integrating metadata from the disease cases with genome variations, ESR is looking to discover possible strain adaptation to the vaccination as well as meningococcal immune evasion and virulence strategies.

To increase the quality of surveillance, as well as looking at past data, ESR is also analysing current disease-causing meningococci in New Zealand with genome sequencing.

This research project is one of the most comprehensive analyses of a major, prolonged meningococcal epidemic to date. It will aid the understanding of how an epidemic starts and spreads, as well as discover possible immune evasion and virulence factors. The results from this three-year research project will contribute a wealth of knowledge to the efforts to reduce the burden of this serious infectious disease.

GROWING INNOVATION THROUGH THE PIONEER FUND



ESR's Pioneer Fund seed-funds internal research in fast-win/fast-fail projects that have the potential to be of commercial value to New Zealand and to increase impact in the areas in which we work. This year 31 projects were funded and research ranged from such things as whether faecal indicator bacteria, such as *E. coli* and enterococci are present in the gut of poikilotherms, (fish and gastropods) at levels that could affect water quality assessments in New Zealand. We are developing optimal sampling methods and analysis of microplastics from a range of environmental samples using forensic physical evidence methods and designing and creating an artificial intelligence model capable of interpreting the drug spectra processed by a Fourier-transform infrared spectroscope (FTIR).

CELEBRATING OUR PEOPLE

RECOGNISING OUTSTANDING SCIENCE

ESR people continue to distinguish themselves, gaining accolades both nationally and internationally. Here are some of the awards and appointments made to them in this year.

SCIENCE NEW ZEALAND NATIONAL AWARDS 2017

INDIVIDUAL LIFETIME ACHIEVEMENT AWARD



Murray Close is a Principal Scientist at ESR in Christchurch and leads the Groundwater Contamination research team. He has over 38 years' experience and a wide knowledge of groundwater conditions and processes throughout New Zealand.

He has led several large multi-year, multi-agency research projects in the area of groundwater research over the past 20 years, including a three-year joint New Zealand-Korea project on groundwater remediation processes.

Currently, Murray leads a multi-year project on enhancing mitigations of nitrate in shallow groundwater systems (\$1.5m per year) involving researchers from ESR, Lincoln Agritech, Aqualinc Research and University of Canterbury. He also leads ESR's Groundwater Modelling of Contaminant Transport project and coordinates the National Survey of Pesticides in Groundwater every four years.

His current interests include pesticide contamination of groundwater, measurement and modelling of attenuation of contaminants in groundwater, unsaturated (vadose) zone processes, regional and national groundwater quality assessment, remediation of contaminated groundwater, groundwater ecosystems, and land-use impacts on groundwater quality. Murray has authored or co-authored 87 articles in peer-reviewed journals and three book chapters.

EARLY CAREER ACHIEVEMENT AWARD



Dr Jo-Anne Bright, Senior Science Leader at ESR, has been instrumental in the development of STRmix™, and she has an extensive list of published papers, despite only receiving her PhD within the last three years. She has 18 years' experience in forensic casework, quality management and training within the laboratory. In 2015, Jo-Anne was awarded her

PhD in Forensic Science from the University of Auckland.

She has over 60 publications in peer-reviewed journals in the area of forensic DNA analysis and interpretation and is one of the co-developers of STRmix™ software used internationally for the probabilistic genotyping of forensic DNA profiles. Jo-Anne has undertaken over 40 presentations and workshops on DNA profile interpretation in Australasia, the US and Europe.

NZ SCIENCE NATIONAL TEAM AWARD

The Forensic Biology team contributes to solving crime in New Zealand through the management of the DNA Profile Databank (DPD) and the team's pioneering spirit in DNA profiling.

The DPD is administered by ESR on behalf of the Police. New Zealand was the second country in the world to create a databank, and this proactive approach to crime has resulted in a high success rate in producing valuable leads for unsolved cases.

The databank operation involves two databases – the DPD (profiles of individuals) and the Crime Sample Database (profiles from unsolved crimes). By comparing the two, possible suspects can be identified and crimes linked. Since the operational start of the databank in 1996, more than 194,000 individual profiles have been completed in the DPD.

New Zealand leads the world in DNA matching with nearly 70% of all unsolved cases loaded to the crime sample databases successfully linked to individuals and 30% linked to another crime.



INTERNATIONAL AWARDS

CHARLES C. SHEPARD SCIENCE AWARD, 2018

Centers for Disease Control and Prevention,
US Department of Health and Human Services.
Sue Huang, Claire Newbern, Liza Lopez, Don
Bandaranayake, as part of the collaborator network
for *Estimates of global seasonal influenza-associated
respiratory mortality: a modelling study*.

AWARD FOR OUTSTANDING PUBLIC HEALTH SCIENCE

Centres for Disease Control and Prevention,
US Department of Health and Human Services.
Sue Huang, Claire Newbern, Liza Lopez, Don
Bandaranayake.

AUSTRALASIAN EVALUATION SOCIETY (AES) AWARD FOR EXCELLENCE IN INDIGENOUS EVALUATION

ESR Social Scientists
Maria Hepi and Jeff Foote for the evaluation of how
Hokianga hapū have utilised the Ministry of Health's
Drinking Water Assistance Programme to access safe
drinking water.

SOCIO-ENVIRONMENTAL SYNTHESIS CENTRE STUDY AWARD, MARYLAND, USA

ESR Scientist
Graeme Nicholas.

SPECIAL LIBRARIES ASSOCIATION SLA FELLOWSHIP

ESR Information Specialist
Kevin Adams

NATIONAL AWARDS

KIWINET EMERGING INNOVATOR AWARD

Amanda Inglis
PhD student, ESR Water Microbiology team for further
exploration using enzymes to inactivate viruses present in
wastewater.

APPOINTMENTS

Keith McLea
Special Advisor, China Council for International Cooperation
on Environment and Development.

Graeme Nicholas
Member, Socio-Environmental Synthesis Centre – Co-
Creative Capacity, Annapolis, Maryland, USA.

Brent LeVert
Member, GICNT Nuclear Forensics Working Group Expert
Meeting, Bangkok, Thailand.

Libby Harrison
Chair, Emerging Scientist Awards Selection Committee.

Matt Russell
Member, Seminar Programme Committee – Clandestine
Laboratory Investigating Chemists Association.

Matt Russell
Member, Editorial Committee – *Journal of the Clandestine
Laboratory Investigating Chemists Association*.

Louise Weaver
Member, Water NZ Technical Committee, Wellington.

Theo Sarris
Chair, International Association of Hydrogeologists NZ
Chapter.

Chris Nokes, Jan Gregor, Lee Burbery, Brent Gilpin, Elaine
Moriarty and Oksana Golovko

Members, Ministry of Health Drinking-water Advisory
Committee Working Group.



OUR PEOPLE



Keeping people safe and healthy through science is only possible when we put our people at the centre of what we do.

OUR PEOPLE

Keeping people safe and healthy through science is only possible when we put our people at the centre of what we do.

To meet the science needs of New Zealand, deliver to our customers, and increase revenue, we work to attract, retain and develop a capable high-performing workforce. We want to ensure our people have the right tools, structures, skills, training and development opportunities to advance their capabilities, develop their careers and grow their professional and personal skill base.

WORKFORCE PROFILE

ESR employs more than 400 expert minds whose independent scientific advice and services help improve our collective economic and social wellbeing.

The majority of our staff (81%) are employed in science or science support roles. We value diversity and benefit from the knowledge and unique perspectives of a workforce that includes people of New Zealand European, Māori, Pasifika and Asian origin. Women represent nearly two-thirds of our employees and work at all levels and in all roles in our organisation.

We have a high-performance culture but encourage work-life balance and enable flexible work practices. Just over 19% of our staff work part-time. Our workforce turnover for the year ending 30 June 2018 was just 6.32%.

We work to attract, retain and develop a capable high-performing workforce

WORKFORCE STATISTICS

	Actual as at 30 June 2017	Actual as at 30 June 2018
Number of full-time staff	331	330
Number of part-time staff +	78	78
Total staff =	409	408
% staff engaged in science	82%	81%
% female staff	66%	65%
% male staff	34%	35%
% aged 20–40 years	37%	36%
% aged 41–60 years	54%	54%
% aged 60+	9%	10%
Disability profile	<1%	<1%
ETHNICITY PROFILE		
NZ European	246	230
Pacific peoples	7	8
Asian	52	63
Māori	7	8
Other European	93	95
MELAA*	4	4

*Middle Eastern, Latin American and African.

BEING A GOOD EMPLOYER

This year, we continued to demonstrate our commitment to being a good employer and advocating organisation-wide equal employment opportunity (EEO) practices relating to the recruitment and selection, development, management and retention of all staff.

The table below outlines our achievements against the seven key elements of being a good employer, as set out by the New Zealand Human Rights Commission.

GOOD EMPLOYER KEY ELEMENTS	WHAT WE DELIVERED 2017-2018
LEADERSHIP, ACCOUNTABILITY AND CULTURE	<ul style="list-style-type: none"> → We held targeted executive leadership and leadership workshops and coaching for people managers and future leaders, with a focus on strengthening the capability of our leaders to effectively champion a high-performing, customer-centred culture. → Our leadership team communicated the strategic direction and organisational goals to staff at all levels. → Our performance management and development process is designed to build a high-performance culture through clear accountability, defined work outputs and alignment with organisational goals and business plans. → Our awards scheme encouraged leadership and accountability and is aligned with our values.
RECRUITMENT, SELECTION AND INDUCTION	<ul style="list-style-type: none"> → Recruitment and selection processes are in place that foster EEO principles. Recruitment is focused on competencies, values, skills and experience and backed by appropriate assessment and selection tools to ensure the best candidate is selected in a fair and equitable manner. → Our new employees received a thorough induction programme that included familiarisation with key policies and processes. → We continued to systemise our recruitment practices and approvals in order to increase consistency across the organisation.
EMPLOYEE DEVELOPMENT, PROMOTION AND EXIT	<ul style="list-style-type: none"> → Our performance management and development system encouraged employees' development by providing clear and achievable progression through building technical skills and behavioural competencies. We offered on-the-job opportunities, internal secondments and attendance at national and international science conferences. → Our performance management framework and online system are now well embedded and have resulted in a more efficient process, greater transparency and more meaningful performance discussions. → Our annual science promotions process supported career progression for our staff. → Employees who leave ESR are offered the opportunity to participate in either an online or a face-to-face exit interview. The feedback is consolidated and used to determine how we can build on areas of strength and improve our working environment.
FLEXIBILITY AND WORK DESIGN	<ul style="list-style-type: none"> → We promoted flexible working arrangements with our flexible hours, extended flexitime, and other flexible working arrangement policies, which are outlined in our employee handbook. We supported parents returning to work by offering part-time and gradual return to full-time work arrangements. As at 30 June 2018, 19% of our employees work part-time. → We introduced a paid volunteering day for staff, which aims to support staff who wish to contribute to the wider community through volunteer work, and this has been well received.

**GOOD EMPLOYER
KEY ELEMENTS**
WHAT WE DELIVERED 2017-2018

REMUNERATION, RECOGNITION AND CONDITIONS	<ul style="list-style-type: none"> → Our terms and conditions of employment are consistent with the good employer philosophy, with a range of benefits valued by our employees. → We reward people fairly and equitably on the basis of contribution, regardless of gender, age or ethnicity. Our performance management and remuneration framework ensures staff feel valued, recognised and appropriately rewarded for their contribution to help nurture a high-performance culture. → We have two annual staff awards that recognise and celebrate individuals or teams for their achievements.
HARASSMENT AND BULLYING PREVENTION	<ul style="list-style-type: none"> → Our acceptable behaviour policy sets out the standards of behaviour expected of all our people, how to deal with unacceptable behaviour including harassment and bullying, and where to access further information and support if required, including the Employee Assistance Programme (EAP). → New employees are introduced to this policy and given training as part of their induction. The policy is reviewed regularly. → We introduced a code of conduct that sets out standards of behaviour that we expect from each other, including legal requirements and key principles from ESR policies. → We align our approaches with the bullying guidelines produced by WorkSafe to ensure we are following best practice.
SAFE AND HEALTHY ENVIRONMENT	<ul style="list-style-type: none"> → Our health and safety policies and procedures are under review and we are working towards the ISO 45001 standard for occupational health and safety management systems. → We have implemented improved reporting and an electronic platform for hazardous substances health and safety management and we are updating all training systems, guidelines and supervision in relation to the new Health and Safety at Work (Hazardous Substances) Regulations 2017. → All employees are given comprehensive training, guidelines and supervision to ensure everyone's safety, health and wellbeing at work. → Nearly one-third of our staff participated in the first New Zealand Workplace Barometer programme run by Massey University's Healthy Working Group. → EAP has been extended to include a trauma support programme providing tailored support to assist staff in dealing with the physical or psychological symptoms that are associated with exposure to traumatic events, unpleasant information or ongoing traumatic experiences as part of their roles. → We introduced a Speak Up programme as part of our protected disclosures policy, which is designed as a channel for employees to report serious wrongdoing in the workplace. It helps us to contribute to a safe and lawful workplace that reflects our organisation's values.

EVERYONE ON AN EQUAL FOOTING

ESR is committed to a diverse and inclusive workplace where all our staff have equal opportunities to fulfil their potential and make their contribution. All our policies and practices are based on the principles of fairness, equity and non-discrimination and are regularly reviewed and refreshed to ensure they remain relevant and fit for purpose.

PARTNERSHIP FOR QUALITY

We continued to work closely with the Public Service Association (PSA) to ensure our employees have a channel where they can communicate recommendations or suggestions for policies, practices and programmes to ESR management. Our Partnership for Quality forum is offered jointly with the PSA and is a way for our people to discuss issues affecting staff and feel listened to and validated.

ENGAGED PEOPLE

A staff engagement survey was completed in March 2018. The survey gives our employees an opportunity to acknowledge things that matter to them while providing valuable insights into their views on our organisation including culture, leadership, health and safety, performance and recognition. It also allows us to benchmark and measure effectiveness of what we are doing against past years to ensure a capable and engaged workforce.

We had a participation rate of 84%. Overall results showed that 52% of staff were engaged with the organisation. The number of disengaged staff remained consistent with last year at 9%. As a result of the staff surveys, we are making a concerted effort to develop and follow through action plans in each group so we can continue to do the things we do really well, and address those the things that need improving.

HEALTH AND SAFETY PROGRESS

At ESR, health and safety is not one person's job – it is everybody's responsibility. To this end, ESR is committed to continual improvement and excellence in the management of health and safety in the workplace. Our aim is to provide and maintain a healthy and safe working environment for all employees, contractors and visitors.

The nature of our work means that staff can be exposed to physical, chemical, psychological and biological hazards. In response we have developed a strong health and safety culture with all employees given comprehensive training, guidelines, mentoring and supervision, and all policies are aligned with the Health and Safety at Work Act 2015. Our total recordable injury frequency rate was 3.01 injuries per 100 full-time equivalents.

EXPECTATIONS OF BEHAVIOUR

A new code of conduct was introduced setting out the standards of behaviour we expect from each other. The code was developed with feedback from staff and sets out the important role all staff have in making ESR a good place to work. At its essence, it encourages staff to act in a way that reflects ESR's values. The nature of our work requires us to maintain the highest standards of integrity, discretion and ethical conduct in order to maintain and enhance the public's trust and confidence in ESR.

SPEAKING UP ABOUT WRONGDOING

The Speak Up programme provides our people with a variety of ways to report serious wrongdoing in the workplace. It helps contribute to a safe and lawful workplace that reflects the organisation's values and code of conduct. The programme sets out the different types of wrongdoing that have different reporting channels and are handled in different ways. This includes speaking to management, human resources, PSA representatives or to a new external channel – the Speak Up phone line channel provided by an external Employee Assistance Programme (EAP) provider.

DEVELOPING OUR LEADERS

Effective leadership is recognised at ESR as being crucial to support a high-performance organisation. A leadership development programme is in place to grow our leaders and ensure they have the skills and mind-set to build the capability of their teams, lead our culture, and facilitate growth, change and innovation. The programme has two sections: the Connect Leaders programme for managers and team leaders with direct reports and the Key Influencers programme for senior staff who play a key leadership role across the organisation. Since its inception, 25% of our staff have been through this programme.

SUPPORTING WORK-RELATED TRAUMA

Our Trauma Support Programme provides access to counselling, education, training, peer support and monitoring, and critical incident support helps staff deal with the physical and psychological symptoms that are often associated with exposure to unpleasant information and potentially traumatic situations. All forensic teams also now undertake at least an annual 'well check' with a skilled psychologist or counsellor from ESR's EAP provider. This is a preventative approach focused on early identification and management of issues.

WALKING THE TALK

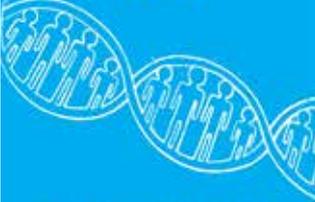
An employee-led sustainability committee was resurrected this year to develop a sustainability policy, and set out actions for ESR to reduce our environmental footprint. Besides a good recycling programme, as a start, and to get staff thinking, ESR has removed all plastic and polystyrene cups from the cafeteria and provided an alternative solution – glass cups, as well as encouraging staff to bring their own drinking bottles.

COPING WITH CHANGE

As with all organisations, ESR is embarking on a change programme so that we are better able to meet the challenges to our business that the future technological and scientific change will bring. For our people, change can be unsettling, and the associated stress can affect health and wellbeing. To help mitigate this, we ran a series of wellness workshops that were attended by over 50% of our employees. These workshops are a step in the right direction by giving some practical tools and advice on navigating times of change and uncertainty.

OUR VALUES

Our values ensure we are **trusted** advisors, delivering **leading-edge** science solutions and **quality services** for the **greater good** of our organisation and beyond.

<p>Our team spirit <i>Mahi tahi</i></p>  <p>GREAT PEOPLE WORKING TOGETHER AS ONE TEAM</p> <p>WE VALUE EACH OTHER BY:</p> <ul style="list-style-type: none"> ✔ sharing our ideas and integrating our science to achieve success for ESR and New Zealand ✔ recognising and celebrating our work and achievements ✔ appreciating the unique perspectives, knowledge and experience that give us our point of difference 	<p>Our quality counts <i>Mahi rangatira</i></p>  <p>STANDING OUT THROUGH OUR EXCELLENCE AND WORLD CLASS EXPERTISE</p> <p>WE DELIVER EXCEPTIONAL QUALITY BY:</p> <ul style="list-style-type: none"> ✔ taking the time to plan and do the job right ✔ understanding our customers and meeting their needs ✔ investing in our people, research and technologies 	<p>We do the right thing <i>Mahi pono</i></p>  <p>UPHOLDING INTEGRITY AND INDEPENDENCE NO MATTER WHAT</p> <p>WE DO THE RIGHT THING BY:</p> <ul style="list-style-type: none"> ✔ delivering science that is evidence-based, objective and impartial ✔ keeping our promises and being accountable to each other ✔ making decisions and choosing actions that are honest, fair and respectful 	<p>We push boundaries <i>Mahi auaha</i></p>  <p>MEETING CHALLENGES WITH FRESH THINKING AND CREATIVE APPROACHES</p> <p>WE PUSH BOUNDARIES BY:</p> <ul style="list-style-type: none"> ✔ embracing a culture of curiosity and learning ✔ creating opportunities to innovate and collaborate ✔ critiquing and learning from what we have done
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STAFF AWARDS – RECOGNISING EXCELLENCE

Each year, ESR recognises and celebrates those people who have done an outstanding job either delivering exceptionally high-quality science and research, or giving an exemplary display of our values.

This year 68 people were nominated by both peers and management making the process both meaningful and team-spirited.

ESR AWARD RECIPIENTS 2017 – 2018

SCIENCE EXCELLENCE AWARDS



Winner

Liping Pang, for her outstanding achievements in research including being awarded three highly competitive research grants this past year, her successful collaborations within New Zealand and internationally and her published works.

Highly commended

- Mehnaz Adnan, for her leadership and innovation in the use of social media as a key tool for syndromic surveillance of illness, recognised by the Ministry of Health as part of a possible early warning system for outbreaks.
- Joanne Hewitt, for her outstanding achievements as an internationally recognised expert on norovirus, her contributions to the understanding of hepatitis A, and her extensive published works.
- Ben Bogun, for undertaking two significant bodies of research in the last year, resulting in a research paper on t-boc-methamphetamine and the first published paper evaluating the use of benchtop NMR for forensic purposes.

LIVING OUR VALUES AWARDS – FOR COMMITMENT TO AND DISPLAY OF OUR ORGANISATION'S VALUES

Winner

Denis Snelgrove, Facilities Maintenance Technician, for his response during the Wellington earthquakes and floods in November 2016.

Highly commended

Lee van Diggele, Lynne St. Clair-Chapman, Frank Woolf, Alison Colgate, Rob Wylie, Jacqui Horswell, Graham Ogden, Elayne Gentry, Donna-Marie Warren, Jan Gregor, Ross Tompkins, Kate Buckingham, Maria Faleusu, Jayshree Patel, Nishu Sachdeva.

STUDY AWARDS – TO ENHANCE STAFF DEVELOPMENT THROUGH FURTHER STUDY GRANTS

Cameron Johnson, Ben Bogun, Jo-Anne Bright, Hannah Kelly, Catherine McGovern, Rebecca Richards, Maarten Kruijver, John Buckleton, Brent Gilpin, Jan Gregor, Tom Sheehan, Mickayla Dustin, Amelia Gamblin, Bradley Ivory, Alison Colgate.

BEST PAPER IN A PEER-REVIEWED JOURNAL

Jo-Anne Bright, Hannah Kelly, Catherine McGovern, John Buckleton: Internal validation of STRmix™ – a multi-laboratory response to PCAST. *Forensic Science International: Genetics*.

BEST PAPER BASED ON OPERATIONAL ACTIVITIES IN A PEER-REVIEWED JOURNAL

Cameron Johnson and Ben Bogun. Analysis of hydrolysis reactions and yields of methamphetamine from liquid containing N-tert-buoxycarbonyl-methamphetamine (t-BOC-methamphetamine). *Journal of the Clandestine Laboratory Investigating Chemists Association*.

OUR SENIOR LEADERS

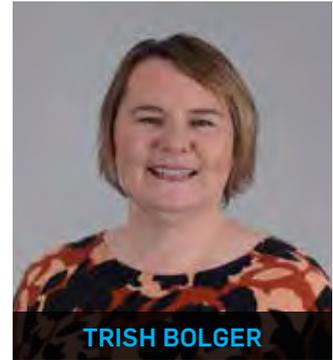
The ESR senior leadership team for year ending June 2018



DR KEITH MCLEA



DR GRAEME BENNY



TRISH BOLGER



JOHN BONE



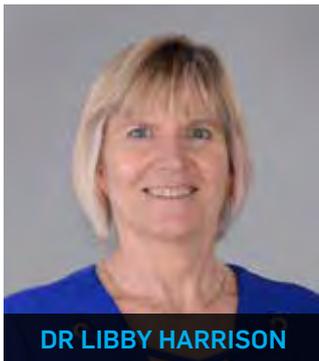
CAS CARTER



DR PHIL CARTER



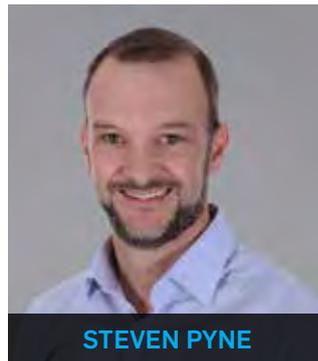
HAMISH FINDLAY



DR LIBBY HARRISON



BRYAN LAU YOUNG



STEVEN PYNE



CELIA WELLINGTON

DR KEITH MCLEA has been Chief Executive of ESR since July 2014. He is Chair of ESR subsidiary STRmix Limited. Keith was appointed Special Advisor to the China Council for International Cooperation on Environment and Development (CCICED) in 2017. He has worked across a number of government agencies providing strategic and policy advice. Keith has a PhD in human genetics and has trained as a toxicologist. He spent much of his professional career working in the personal injury insurance and injury prevention sectors and has been a Director at Cranleigh Strategic Limited.

DR GRAEME BENNY was General Manager, Health at ESR, leaving the company in March 2018. Having worked in executive roles in both the private and public sectors, Graeme brought strong management skills and a proven track record to the organisation. Before coming to ESR, Graeme was the Director of Health Workforce New Zealand and Chief Executive of Careers New Zealand. Graeme earned his PhD in clinical biochemistry from the University of Auckland.

TRISH BOLGER took over as General Manager, People from May 2018. Trish has a broad HR background and brings with her considerable HR management experience. Trish's philosophy is that data and evidence should drive the strategic agenda for the business and its people. Her most recent role was as General Manager, People at the New Zealand Racing Board, and previously her HR management roles included working at Phillips Consumer Electronics in the Netherlands, the ANZ Banking Group (NZ) and KPMG. She has a master's in industrial and organisational psychology. Trish manages her own 17-acre olive grove, which has produced award-winning olive oil.

JOHN BONE is General Manager, Forensics at ESR. With over 15 years in senior leadership roles under his belt, John is quick to comprehend technical concepts and their relevance to business problems of complexity and ambiguity. He has a passion for technical innovation, customer relationships and commercial enterprise, and this has been applied to a number of roles across chemical, oil, telco, business services and consulting sectors. These include Operations Manager at Coretex, Head of Strategy and Wholesale at Telstra Clear, Chief Executive of Sytec and Programme Director at Tower Insurance. John is also ESR's director and investor representative on biotech start-up AuramerBio.

CAS CARTER is responsible for ESR's communications and brand management. This includes growing ESR's visibility and brand and the Communications team reports to her. Cas is an experienced executive leader with an extensive background in corporate communications, public relations and marketing. She is a director of marketing and communications company, The Brightside Collective, as well as her own company Cas Carter Communications. She has worked in the public and private sector in a range of senior roles in both education and the tourism industry covering all the vagaries of marketing, communication, a bit of sales and even some fundraising. Prior to that Cas worked as a journalist, news reader and sub editor in both print and radio. Cas was Vice President of the Wellington Chamber of Commerce and a board member of Business Central. She is a regular radio panellist and media columnist.

DR PHIL CARTER is Chief Scientist and Chair of the Strategic Science team. Phil is a molecular microbiologist who has worked at ESR for over 16 years. He is responsible for growing the research programme at ESR and the allocation of strategic funding across ESR science and ESR's scholarships and awards. His research interests include the population genetics of bacterial pathogens including *Neisseria*, *Campylobacter*, *E. coli* O157 and *Salmonella*.

HAMISH FINDLAY is General Manager, Commercial and International. He is also a Director of ESR subsidiary, STRmix Limited. Hamish has extensive experience in business development offshore and in New Zealand, commercialising technology and science from research organisations. He previously served as a Senior Commercialisation Manager at the Ministry of Business, Innovation and Employment, where he advised government and research organisations on commercialisation issues. Prior to that, he worked as Commercialisation Manager for Otago Innovation Limited. Hamish has a Masters (Hons) in Psychology and a Bachelor of Commerce from the University of Auckland. He also earned a Diploma for Graduates in Accounting from the University of Otago.

DR LIBBY HARRISON became General Manager, Health and Environment at ESR when the two areas merged in February 2018. Before that, she was General Manager, Environmental Science at ESR for three years. Libby's understanding of the New Zealand science system coupled with her stakeholder engagement skills has enabled ESR's environmental science business to thrive. Libby has held a number of consulting and senior executive roles including General Manager at Landcare Research and the New Zealand Environmental Protection Authority and Deputy Secretary at the Ministry for the Environment. Originally from the United Kingdom, Libby has a master's and PhD in insect pest control from the University of London and a bachelor's degree in zoology from Oxford University.

BRYAN LAU YOUNG is General Manager, Finance and Business Performance and Chief Financial Officer at ESR. Bryan has over 20 years' experience across a broad range of industries having held senior financial and commercial roles in consulting, telecommunications, financial services and aviation with a focus on lifting organisational financial performance. Prior to joining ESR, Bryan was Head of Finance at Airways New Zealand where he was responsible for commercial relationships with airlines and airports, structuring international growth and acquisition initiatives and leading the newly formed finance, property and procurement team.

STEVEN PYNE is Chief Information Officer at ESR. He has worked at the nexus of science and ICT support for a number of government and corporate organisations, including his previous roles as CIO for the Ministry of Science and Innovation and the Foundation for Research, Science and Technology and before that as Senior Technical Consultant at Eagle Technology. Steven is an avid supporter of collaborative uses of technology to empower science. He has a Bachelor of Commerce and Administration from Victoria University and has recently completed executive development with the Darden School of Business at the University of Virginia.

CELIA WELLINGTON was General Manager, People and Communications at ESR until April 2018. She led the development of many positive and progressive strategies and processes at ESR including the refresh of the organisation's vision and values, the establishment of the Communications team, revising the performance, recognition and remuneration framework and establishing and driving our leadership development programme. Celia has a background as an industrial psychologist and has 20 years' experience in organisational development. She has delivered consultancy services at both an operational and strategic level to a wide range of public and private sector organisations in New Zealand.

OUTCOME PERFORMANCE INDICATORS

For the year ended 30 June 2018

	TARGET	ACTUAL
PUBLIC HEALTH		
Time-critical turnaround times are met	100%	100%
Ministry of Health's satisfaction with ESR's support for responses	Good	Good
Ministry of Health's satisfaction with ESR's services	Good or better	Good
Ministry of Health's project brief milestones and deliverables consistently met	95%	98%
FOOD SAFETY		
New projects addressing food safety needs for regulators and industry	2	2
Iwi/hapū participation in ESR's food-related projects	Increased	Maintained
FORENSIC		
DNA samples linked to a person	70%	70%
DNA samples linked to other crimes	30%	32%
Fulfilment of contractual obligations under the service level agreement	100%	71% (all priority cases met)
Police satisfaction with ESR's timeliness and quality of service	90%	99%
WATER AND THE ENVIRONMENT		
ESR scientists are invited onto an advisory panel and acts as expert witnesses	Increased	6
Project work related to environmental health is increased, e.g. Pacific, China and Southeast Asia	Four new contracts signed	5
Water quality advice and analytical services provided to regional and unitary councils each year	85% of councils	At least 80% of councils
Iwi/hapū participation in ESR's water-related projects	Increased	Maintained

		ACTUAL	TARGET
GENERIC CRI PERFORMANCE INDICATORS			
End-user collaboration	Revenue from commercial and other sources per FTE	\$164,000	\$168,300
Research collaboration	Publications with collaborators	42	65
Technology and knowledge transfer	Commercial reports per scientist FTE	0.54	0.45
Science quality	Impact of science publications (measured using Web of Science citations for the preceding financial year)	3.1	3.1
Financial indicators	Revenue per FTE	\$199,700	\$200,300
	Commercial and other services revenue	\$62.5m	\$67.3m

	ACTUAL 2018	TARGET 2018	ACTUAL 2017
FINANCIAL PERFORMANCE INDICATORS (YEAR ENDING JUNE)			
Revenue	\$76.2m	\$80.2m	\$75.5m
Operating margin <i>Earnings before interest, tax, depreciation and amortisation (EBITDA) as a percentage of revenue</i>	14.2%	13.9%	16.3%
Return (NPAT) on equity <i>Net profit after taxation as a percentage of equity</i>	8.2%	7.7%	10.5%
Return (EBIT) on assets <i>Earnings before interest and tax as a percentage of total assets</i>	7.2%	7.1%	10.1%
Profit volatility <i>The standard deviation of EBITDA as a percentage of average EBITDA over the preceding 7 years</i>	26.6%	n/a	28.2%
Acid test ratio <i>Current assets excluding prepayments and inventory to current liabilities excluding deferred revenue</i>	2.8	1.9	2.7
Equity ratio <i>Equity as a percentage of total assets</i>	71.4%	72.0%	70.7%
Gearing <i>Debt (including finance lease liabilities) as a percentage of debt and equity</i>	0.1%	n/a	0.6%
Operating margin per full-time equivalent employee <i>Earnings before interest, tax, depreciation and amortisation, per average full-time equivalent employee for the year</i>	\$28,300	\$27,900	\$33,700



OUR GOVERNANCE



*Through strong governance, we ensure that
ESR is on the right path.*

CORPORATE GOVERNANCE

The Institute of Environmental Science and Research Limited is a Crown Research Institute incorporated as a company in 1992.

Ownership is held equally between two Shareholding Ministers appointed by the government: The Minister of Research, Science and Innovation and the Minister of Finance.

STATEMENT OF CORE PURPOSE

ESR's shareholder expectations are set out in the Statement of Core Purpose, which defines our purpose, expected outcomes, areas of operation, and operating principles.

ESR's purpose is to deliver enhanced scientific and research services to the public health, food safety, security and justice systems, and the environmental sector to improve the safety of and contribute to the economic, environmental and social wellbeing of people and communities in New Zealand.

STATEMENT OF CORPORATE INTENT

The Statement of Corporate Intent (SCI) sets out ESR's five-year strategy for delivering against the core purpose. It includes the future operating environment, the activities and strategic initiatives that will be undertaken, the outcomes ESR aims to achieve and how performance is measured. It is reviewed annually.

ESR's latest SCI can be found on the ESR website.

GOVERNANCE STRUCTURE

As the owner of Crown Research Institutes, the Crown acts to protect its investment on behalf of New Zealand.

Each CRI has two Shareholding Ministers: the Minister of Research, Science and Innovation and the Minister of Finance. Each Minister has a 50% shareholding, with the Minister of Research, Science and Innovation as the Responsible Minister.

ESR has its own constitution and complies with the operating framework issued annually by its shareholders.

Shareholding Ministers appoint a board of directors to oversee the management of ESR and to appoint a CRI's chief executive in accordance with the Companies Act and its constitution. The Crown also appoints the chair and deputy chair.

The Ministry of Business, Innovation and Employment (MBIE) is the primary monitoring agency for ESR.

ESR's purpose is to deliver enhanced scientific and research services

LEGAL OBLIGATIONS

ESR's complies with all legislation including the following:

- Companies Act 1993
- Crown Research Institutes Act 1992
- Crown Entities Act 2004
- Health and Safety at Work Act 2015
- Official Information Act 1982
- Public Audit Act 2001
- Public Finance Act 1989
- State Sector and Public Finance Reform Act 2012

BOARD OF DIRECTORS ESR

The Board of Directors is accountable to the Minister of Research, Science and Innovation and the Minister of Finance and is ultimately responsible for the strategic direction, legal obligations and operational performance of ESR. The Board delegates responsibility for the management of the organisation to the Chief Executive.

The ESR Board meets 11 times each year at one of three ESR locations in Auckland, Wellington and Christchurch.

ESR Board Composition for the year ending June 2018:

- Denise Church, QSO, Chair
- Marion Cowden, Deputy Chair
- Dr Helen Darling
- Quentin Hix
- Richard Gill
- Professor Cristin Print
- Dr Andrew Shenk

Profiles of ESR's Board can be found on page 80 of this report.

BOARD OF DIRECTORS STRmix LIMITED

(Subsidiary of ESR)

- Keith McLea (Chair)
- Denise Church
- Hamish Findlay

Policy reviews

Key policies reviewed include:

- Delegated financial authority policy
- Internal audit charter policy
- Treasury management policy
- Audit and risk committee terms of reference

BOARD COMMITTEES

There are two Board committees operating under the direction of the Board Chair.

Audit and Risk Committee

The objective of this committee is to assist the Board in discharging its responsibilities in relation to the oversight of risk, control and compliance framework and its external accountability responsibilities.

Members are:

- Marion Cowden (Chair)
- Quentin Hix
- Denise Church

People, Performance and Remuneration Committee

The objective of this committee is to assist the Board in discharging its responsibilities in relation to the oversight of ESR's people strategies, principles and frameworks that support a high-performance culture.

Members are:

- Dr Helen Darling (Chair)
- Denise Church
- Richard Gill
- Professor Cristin Print

STRATEGIC SCIENCE ADVISORY PANEL

The Board also receives advice from the Strategic Science Advisory Panel.

The panel provides independent, expert advice to the Board on research, development and future science initiatives that are aligned with ESR's core purpose.

Members are:

- Dr Ian Elsum, Australian National University
- Professor Mark Gahegan, Auckland University
- Dr Elizabeth Jazwinska, RMIT
- Professor Bruce Weir, University of Washington

Profiles of the Strategic Science Advisory Panel can be found on page 82 of this report.

MANAGING RISK EFFECTIVELY

ESR has in place a risk management framework and associated procedures for effective identification and management of ESR's financial and business risks, including fraud.

Risk management is integrated into a number of other corporate processes including business planning, internal audit and health and safety. Strategic risks are monitored by the senior leadership team and assessed and reported quarterly to ESR's Audit and Risk Committee and the Board.

CODE OF CONDUCT AND ETHICS

As a publicly-funded organisation, we also have a responsibility to maintain the highest standards of integrity, discretion and ethical conduct in order to maintain and enhance the public's trust and confidence in ESR.

Our code of conduct, which was redeveloped recently, reinforces our values and sets out common standards of behaviour that we expect of our staff. It provides a framework that reinforces our commitment to our legal requirements and our policies, standards and principles.

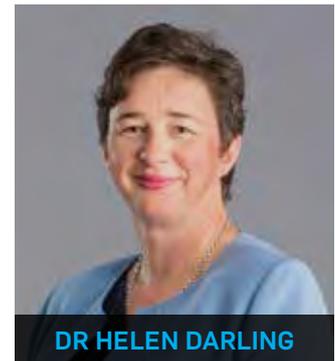
OUR BOARD



DENISE CHURCH



MARION COWDEN



DR HELEN DARLING



RICHARD GILL



QUENTIN HIX



PROF. CRISTIN PRINT



DR ANDY SHENK

DENISE CHURCH, QSO was appointed as Chair of the ESR Board in July 2015 as well as a Director of ESR subsidiary, STRmix Limited in 2018. She is a Director of Leadership Matters Limited, a Wellington-based strategy and leadership consulting practice. She has extensive governance experience including as Chair of Karori Sanctuary Trust, WWF New Zealand, and the Wellington Zoo Trust. Her other board roles have included the National Board of Scouts New Zealand, the National Health IT Board, Ako Aotearoa, Landcare Research, and the Foundation for Research, Science and Technology. Denise was previously Chief Executive of the Ministry for the Environment.

MARION COWDEN is Deputy Chair of the ESR Board and Chair of the Audit and Risk Committee. Marion is a fellow of Chartered Accountants Australia and New Zealand. She holds a BSc and BComm from the University of Auckland and an MBA (with Distinction) from Massey. Marion has held senior roles in finance and corporate services in the New Zealand and Australian public services and with the Commonwealth Secretariat based in London. Her current governance roles include Board Member and Chair of the Audit Committee of the Real Estate Authority and trustee of the Nazareth Care and St John of God Hauora Trust.

DR HELEN DARLING graduated with a PhD in Public Health from the Dunedin School of Medicine, University of Otago and has founded three companies that work in the area of food integrity including a tech start-up that is using artificial intelligence and social media to address food safety issues in the United States. Helen continues to work in the area of commercialisation of food integrity services and is particularly interested in the application of technology to enhance global food supply chains. In addition to industry and business knowledge, she has over 20 years' governance experience. She is currently a member of the United States Pharmacopeial (USP) Convention Food Ingredients Expert Committee and is on the USP's Food Adulteration Expert Panel. She is Chair of the People, Performance and Remuneration Committee.

RICHARD GILL is a technology innovator and serial entrepreneur who has more than 30 years' experience founding and growing high-tech start-ups serving a wide range of industries, including broadcasting, manufacturing, finance, education, healthcare and water. He has worked extensively in technology development, product conceptualisation, early stage commercialisation and high growth execution. He is CEO of events technology start-up Blerter.

QUENTIN HIX has many years' experience in governance roles across a broad range of sectors. He is currently a director of Ngāi Tahu Holdings Limited, one of the South Island's larger investment companies. He is also a member of the main governance board for Ngāi Tahu, and is a board member of Presbyterian Support South Canterbury. Previous roles include chairing Westland Holdings Limited and Trust Aoraki Limited and being a director of Hunter Downs Water Limited, as well as holding a ministerial appointment to the South Canterbury District Health Board. Quentin is a lawyer with experience in most areas of the law. He currently practises mostly in the field of criminal law.

PROFESSOR CRISTIN PRINT is a medically qualified biomedical scientist who joined the ESR Board in August 2017. He has a 25-year career in academic medical research and biotechnology, including work in Australia, the United Kingdom and Japan.

He is a Professor in the University of Auckland's Department of Molecular Medicine and Pathology, where he uses genomic and bioinformatic technologies alongside traditional pathology to better understand human disease.

Cris is currently Chair of the Auckland Regional Tissue Bank's Scientific Advisory Board, a Principal Investigator in the Maurice Wilkins Centre, Director of Auckland's Genomics into Medicine initiative, on the Science Leadership Team of the Healthier Lives National Science Challenge and Vice President of the Auckland Museum Institute.

DR ANDY SHENK graduated with a PhD in Biological Sciences from the University of Delaware and has had a 30-year career spanning academic research, management and governance in biotechnology and nutrition start-up companies and senior management in a major corporate.

Andy currently works across many fields of research, development and commercialisation of intellectual property, including early-stage investing in new technologies here in New Zealand and overseas.



STRATEGIC SCIENCE ADVISORY PANEL



DR IAN ELSUM

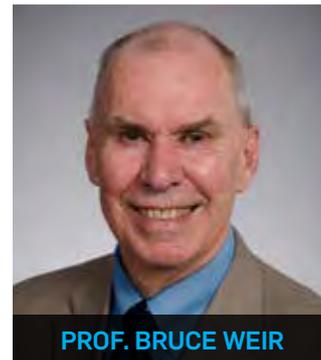


PROF. MARK GAHEGAN



DR ELIZABETH JAZWINSKA

DR IAN ELSUM (PhD, BSc Hons) (Chair) is a Visiting Fellow in the Research School of Management at the Australian National University and an Adjunct Professor in the Centre for Transformative Innovation at Swinburne University of Technology. His research and teaching are focused on the management of innovation. He is a member of the Industrial Research Institute where he has co-chaired projects to improve the management of radical/breakthrough innovation and the challenges of business model innovation in established firms. Past positions include 28 years with CSIRO where he gained extensive experience in the strategic management of applied research and membership of a number of boards and advisory committees in the area of science and technology-based innovation.



PROF. BRUCE WEIR

PROFESSOR MARK GAHEGAN (PhD, BSc) is inaugural Director of the Centre for Eresearch and Professor in the Department of Computer Science at the University of Auckland. Prior to this, he was Associate Director of the GeoVISTA Center, at Penn State University, USA. He has written over 120 peer-reviewed articles, given over 140 invited talks, and been Principal Investigator or Co-Principal Investigator on about 40 funded projects. He serves on the editorial board of eight international journals. He has played a key role in establishing eScience communities within several academic communities: including geosciences, bioinformatics, fungal plant pathogens, digital archaeology, and climate change impacts. He was lead author of the National eScience Infrastructure (NeSI) proposal that was funded by the Ministry of Science and Innovation in 2011, to coordinate support for eResearch and high-performance computing across New Zealand.

DR ELIZABETH JAZWINSKA (PhD, MBA, BSc Hons) has more than 30 years' experience in R&D management and business development and has held senior positions in academia, industry and government. She joined RMIT University in September 2016 where she leads cross-functional research engagement, IP and commercialisation teams responsible for delivering socio-economic impact from RMIT research. She is also Chair of the Governance Board of the Australian Phenomics Network. She has held senior positions in Australian, New Zealand and Singaporean government agencies including Deputy Chief Executive of the Ministry of Science and Innovation. She was Executive Director of New Business & Strategic Alliances at Johnson & Johnson Research Pty Limited (JJR) in Sydney, and previous to that, she held positions in industry and academia. Elizabeth has authored 62 publications in peer-reviewed journals. She holds a BSc (Hons) from Aberdeen University, a PhD from Edinburgh University and an MBA from the Australian Graduate School of Management. She is also a graduate of the Australian Institute of Company Directors.

PROFESSOR BRUCE WEIR (PhD, BSc Hons) is Professor and former Chair of the Department of Biostatistics and Adjunct Professor, Department of Genome Sciences, University of Washington, Seattle. He is also Director of the Institute of Public Health Genetics and of the Genetic Analysis Center at that university. He has a BSc (Hons) with First Class Honours in Mathematics from the University of Canterbury and a PhD in statistics, with a minor in genetics, from North Carolina State University. He is a Fellow of the American Association for the Advancement of Science, the American Academy of Forensic Sciences and the American Statistical Association, and an Honorary Fellow of the Royal Society of New Zealand. Bruce has held numerous editorial positions with journals in genetics, statistics, biometrics, heredity and epidemiology. He has supervised more than 30 PhD students. His research interests are in statistical genomics, with applications to human disease studies and forensic science. He has published over 200 peer-reviewed journal articles, which have gathered 66,000 citations. He has an h-index of 86.





OUR FINANCES



Our strong financial performance enables us to invest in our future growth.

REPORT FROM THE CHIEF FINANCIAL OFFICER



ESR continued to build on the financial achievements of recent years, recording a net profit after tax (NPAT) of \$4.3m. The result exceeded the Statement of Corporate Intent target of \$3.9m.

While down on the record NPAT of \$5.0m in 2017, this is above the previous NPAT highpoint of \$3.8m achieved in 2016 and reflects revenue changes and investment actions as noted below.

REVENUE GROWTH

The result was driven by growth in commercial and research revenues, in both domestic and international markets.

This growth, with an ongoing focus on margins and efficiencies across business and corporate functions, enabled ESR to absorb a 4% reduction in revenue from core government contracts and continue to fund growth in capability for the future.

Commercial revenues grew 9% year on year, driven by the continued growth in the use of ESR's forensic software STRmix™, particularly in North America.

Research revenues increased 20% in 2018, with international contracts building on ESR's expertise and reputation developed with the Southern Hemisphere Influenza and Vaccine Effectiveness Research and Surveillance (SHIVERS) study and domestically with research projects funded by Marsden, the Health Research Council and MBIE Smart Ideas. ESR has also been successful with several MBIE Vision Mātauranga research funding applications, representing tangible progress towards ESR's objective of prioritising Vision Mātauranga research to the benefit of Māori and New Zealand.

INVESTING IN THE FUTURE

Management of ESR's financial performance has the organisation well placed to continue its growth strategy through investing in our staff, application of strategic science investment funding and targeted capital expenditure.

ESR increased the number of full-time equivalent positions during 2018, with seven of these roles targeted specifically at growing ESR's data science and research capabilities. Additional scientific and technical roles were added to support service delivery and research, and corporate and infrastructure functions were also strengthened.

Operating cash flows supported a substantial increase in capital expenditure in 2018 as well as the continued accumulation of cash reserves to fund longer-term investment plans including the replacement of ageing science facilities.

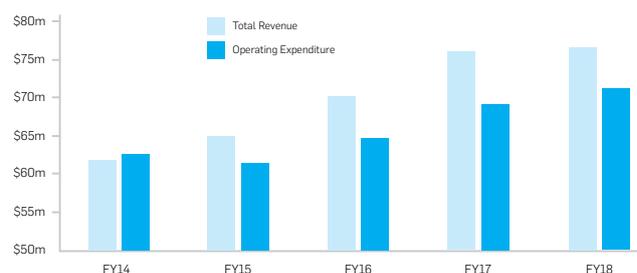
Total capital investment increased 90% in 2018 to \$5.9m, with significant investment in:

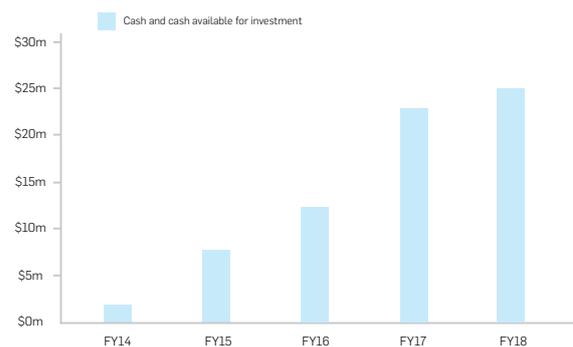
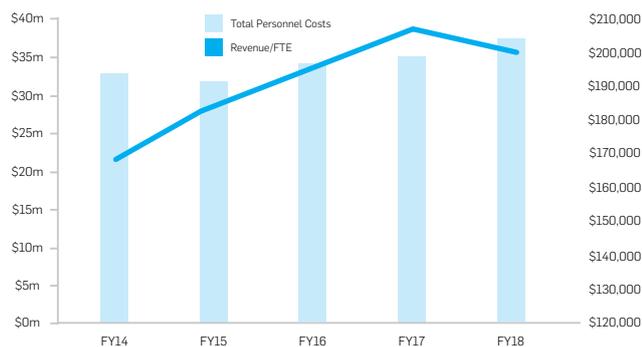
- scientific equipment to increase capability, support service delivery and research objectives, including continued development of ESR's genomics capabilities
- IT infrastructure and software, supporting business applications, bioinformatics infrastructure, video-conferencing facilities and maintenance of key finance and laboratory systems
- facilities infrastructure
- continued development of STRmix™ and related software.

ESR continues to make progress towards addressing the issue of science facilities approaching the end-of-useful-life. An indicative business case for the redevelopment of ESR's Kenepuru facility was completed in June 2018. Operating cash flows continue to increase cash reserves that will be utilised to fund the development of replacement facilities.

Financial performance

\$000	Actual 2018	SCI Target	Actual 2017
Revenue	76,159	80,154	75,511
Operating margin	10,801	11,167	12,308
NPAT	4,271	3,897	5,009
Return on equity	8.2%	7.7%	10.5%





Five year trends

	2014	2015	2016	2017	2018
Revenue	\$ 61.8m	\$65.0m	\$70.1m	\$75.5m	\$76.2m
Operating margin	8.1%	13.9%	15.5%	16.3%	14.2%
Return on equity ¹	-1.4%	6.5%	8.9%	10.5%	8.2%
Return on assets ²	-1.3%	6.0%	8.6%	10.1%	7.2%
Acid test ratio	1.3	1.5	1.7	2.7	2.8
Equity ratio	67.8%	67.3%	71.3%	70.7%	71.4%
Operating margin per FTE	\$13,230	\$25,600	\$30,500	\$33,700	\$28,300

¹ Net profit after tax to average equity

² Earnings before interest and tax to average total assets

Capital investment

	2014	2015	2016	2017	2018
Property, plant and equipment	\$2.4m	\$2.4m	\$4.5m	\$2.6m	\$4.1m
Intangible assets	\$2.2m	\$3.9m	\$1.3m	\$0.5m	\$1.5m
Investments	\$0.03m	–	–	–	\$0.3m
Total capital expenditure	\$4.6m	\$6.2m	\$5.8m	\$3.1m	\$5.9m

Capital structure

	2014	2015	2016	2017	2018
Equity	\$38.6m	\$41.1m	\$45.0m	\$50.0m	\$54.3m
Total assets	\$57.7m	\$60.8m	\$63.1m	\$70.7m	\$76.0m
Shareholders funds to total assets	67.8%	67.3%	71.3%	70.7%	71.4%

Bryan Lau Young

Chief Financial Officer

FINANCIAL STATEMENTS AND REPORT OF DIRECTORS

Institute of Environmental Science and Research Limited

For the year ended 30 June 2018

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Statement of Responsibility

We certify that the Company has operated in accordance with the principles of the Crown Research Institutes Act 1992 and Companies Act 1993. The Company has also complied with all statutory environmental regulations.

We acknowledge responsibility for the preparation of these financial statements and for the judgements used therein.

Internal control procedures are considered to be sufficient to provide reasonable assurance as to the integrity and reliability of the financial reports.

In our opinion these financial statements fairly reflect the financial position and operations of the Institute of Environmental Science and Research Limited (ESR) for the year ended 30 June 2018.

**Denise Church QSO**

Chair

**Quentin Hix**

Deputy Chair

Report of the Directors

The directors present the Annual Report and audited financial statements of the Institute of Environmental Science and Research for the year ended 30 June 2018.

The Auditor-General is the statutory auditor pursuant to section 21 of the Crown Research Institutes Act 1992. The Auditor-General has appointed Chris Ussher, using the staff and resources of PricewaterhouseCoopers, to audit the financial statements and to express an opinion on them.

Principal activity

ESR is a Crown Research Institute that provides specialist scientific services and research, particularly to the health and justice sectors. Its purpose is to deliver enhanced scientific and research services to the public health, food safety, security and justice systems, and the environmental sector to improve the safety and contribute to the economic, environmental and social wellbeing of people and communities in New Zealand.

Dividends

No dividends have been declared or paid in respect of the 2018 financial year.

Directors' indemnity

ESR has arranged for directors and officers insurance for any act or omission in their capacity as a director of the Company.

Directors' use of information

ESR has arranged for directors and officers insurance for any act or omission in their capacity as a director of the Company.

Directors' use of information

No member of the Board of ESR, or any subsidiary, issued a notice requesting to use information received in their capacity as directors that would not otherwise have been available to them.

Donations

No donations were made during the year.

Remuneration of Directors

The directors who held office in the period of this report and their total remuneration and other benefits were:

Denise Church (Chair)	\$48,065
Quentin Hix (Deputy Chair)	\$24,033
Marion Cowden (retired 30 June 2018)	\$30,040
Dr Helen Darling	\$24,033
Richard Gill	\$24,033
Cristin Print (appointed 14 August 2017)	\$21,247
Andrew Shenk (appointed 14 August 2017)	\$21,247
	\$192,698

Disclosure of interests by Directors

As at 30 June 2018 the following directors had made the following general disclosures:

Denise Church (Chair)

Chair, Karori Sanctuary Trust

Trustee, Scout Youth Foundation

Director and Shareholder, Leadership Matters Limited

Member, National Board, Scouts New Zealand

Director, STRmix Limited

Quentin Hix

Board member, Te Rūnanga o Ngāi Tahu
 Director, Ngāi Tahu Holdings Corporation Limited
 Trustee, Hunter Downs Irrigation Trust
 Director, Quentin Hix Legal Limited
 Trustee, Q C S & K L Hix Family Trust
 Trustee, The T A H R K Hix Family Trust
 Opus approved RMA Commissioner and Chair
 Board Member, Presbyterian Support South Canterbury
 Director, Presbyterian Support Services (South Canterbury) Limited
 Director, One to One Corporate Trustees Limited
 Director, One to One Corporate Trustees 2011 Limited
 Director, Dunedin City Holdings Limited
 Director, Dunedin City Treasury Limited
 Director and Shareholder, Property Planit Limited
 Director, Aoraki Management Services Limited
 Director, Aoraki Investments Limited
 Director, Aoraki Trust Management Limited

Marion Cowden (retired 30 June 2018)

Board Member, St John of God Hauora Trust
 Trustee, Nazareth Care Charitable Trust
 Age Concern (Wellington) – part-time Executive Officer
 Member, Real Estate Authority
 Director and Shareholder, Muireall Otaghair Properties Limited

Dr Helen Darling

Director and Shareholder, Cherry Futures Limited
 Director and Shareholder, Asia Pacific Centre for Food Integrity
 Expert Committee, United States Pharmacopeial Convention, Food Ingredients
 Expert Panel, United States Pharmacopeial Convention, Food Adulteration
 Director and Shareholder Sumfood Limited

Richard Gill

Director, Shareholder and CEO, Cloud M Limited
 Director and Shareholder, Richard Gill Limited
 Director, Richard Gill Trustees Limited
 Director and Shareholder, Sumfood Limited

Cristin Print (appointed 14 August 2017)

Member, Science Leadership Team of Genomics Aotearoa
 Professor, Dept of Molecular Medicine and Pathology, University of Auckland, and lead of the University of Auckland Genomics into Medicine programme
 Standing member, Assessment Committee of Cancer Research Trust NZ
 Principal Investigator, Maurice Wilkins Centre
 Member, New Zealand eScience Infrastructure Research Reference Group
 Chair, Auckland Regional Tissue Bank Scientific Advisory Board
 Member, University of Auckland eResearch Advisory Board
 Member, Science Leadership Team, 'Healthier Lives' National Science Challenge

Andrew Shenk (appointed 14 August 2017)

CEO, Auckland UniServices Limited
 Director, The Icehouse Limited
 Advisor, Zino Ventures Limited
 Advisor, 88Kiwis Limited
 Hop Revolution Limited
 Hop Revolution 1 Limited

Directors' interests

No director held any interest in the shares of ESR. ESR has funding contracts with the Marsden Fund and the Ministry of Business, Innovation, and Employment, which are negotiated at arm's length with appropriate directors' interests being declared. Except for these contracts no material contracts involving directors' interests were entered into during, or subsequent to, the period covered by this report.

Remuneration

Total remuneration in respect of employees paid above \$100,000 was as follows:

Remuneration Range	No. of Staff
\$100,000 – 109,999	36
\$110,000 – 119,999	11
\$120,000 – 129,999	13
\$130,000 – 139,999	10
\$140,000 – 149,999	6
\$150,000 – 159,999	1
\$160,000 – 169,999	4
\$170,000 – 179,999	3
\$180,000 – 189,999	1
\$190,000 – 199,999	1
\$200,000 – 209,999	2
\$210,000 – 219,999	1
\$230,000 – 239,999	1
\$240,000 – 249,999	4
\$310,000 – 319,999	1
\$470,000 – 479,999	1

Events subsequent to balance date

The directors are not aware of any matter or circumstance since the end of the financial year that has significantly affected, or may significantly affect, the operation of ESR.



Denise Church QSO
Chair



Quentin Hix
Deputy Chair



Independent auditor's report

To the readers of the Institute of Environmental Science and Research Limited's financial statements for the year ended 30 June 2018.

The Auditor-General is the auditor of the Institute of Environmental Science and Research Limited and its subsidiaries (the Group). The Auditor-General has appointed me, Chris Ussher, using the staff and resources of PricewaterhouseCoopers, 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 97 to 117, that comprise the statement of financial position as at 30 June 2018, the statement of profit or loss and other comprehensive income, statement of changes in equity and statement of cash flows for the year ended on that date and the notes to the financial statements that include the statement of significant 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;
 - 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 23 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). 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.

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 financial statements. We are responsible for the direction, supervision and performance of the Group audit. We remain solely responsible for our audit opinion.

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

Our responsibilities arise from the Public Audit Act 2001.

Other Information

The Board of Directors is responsible for the other information. The other information comprises the information included on pages 89 to 92, but does not include the financial statements, and our auditor's report thereon.

Our opinion on the financial statements does not cover the other information and we do not, and will not, express any form of audit opinion or assurance conclusion thereon. At the time of our audit, there was no other information available to us in relation to the annual report.

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



Independence

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

In addition to the audit we have carried out engagements in the areas of other assurance services, taxation compliance and advice and cyber security workshops. Other than the audit and these engagements, we have no relationship with or interests in the Group.

A handwritten signature in black ink that reads 'Chris Ussher'.

Chris Ussher

On behalf of the Auditor-General
Wellington, New Zealand

A handwritten signature in black ink that reads 'PricewaterhouseCoopers'.

PricewaterhouseCoopers

Statement of Profit or Loss and Other Comprehensive Income

for the year ended 30 June 2018

Group	Note	Actual 2018 \$'000s	Budget 2018 (unaudited) \$'000s	Actual 2017 \$'000s
Operating revenue				
Revenue from rendering of services		66,925	70,920	66,277
Strategic science investment funding		9,234	9,234	9,234
		76,159	80,154	75,511
Operating expenses				
Scientific materials		5,940	6,095	5,799
Subcontracting expenses, commissions and royalties		7,942	9,025	8,610
Personnel		37,065	37,636	34,950
Depreciation and amortisation	4/5	5,538	6,102	5,525
Other	2	14,411	16,231	13,844
		70,896	75,089	68,728
		5,263	5,065	6,783
Operating profit				
Interest income		766	456	336
Finance expense		(10)	(15)	(38)
Net finance income		756	441	298
		6,019	5,506	7,081
Profit before income tax expense				
Income tax expense	3	1,748	1,609	2,072
Profit for the period attributable to the shareholder of the parent		4,271	3,897	5,009
Other comprehensive income		–	–	–
Total profit or loss and other comprehensive income for the period attributable to the shareholder of the parent		4,271	3,897	5,009

The accompanying notes form an integral part of these financial statements.

Statement of Changes in Equity

for the year ended 30 June 2018

Group	Share Capital \$'000s	Retained Earnings \$'000s	Total Equity \$'000s
Balance at 30 June 2016	8,494	36,496	44,990
Profit for the period	–	5,009	5,009
Other comprehensive income	–	–	–
Total comprehensive income	–	5,009	5,009
Transactions with owners:			
Dividend	–	–	–
Balance at 30 June 2017	8,494	41,505	49,999
Balance at 30 June 2017	8,494	41,505	49,999
Profit for the period	–	4,271	4,271
Other comprehensive income	–	–	–
Total comprehensive income	–	4,271	4,271
Transactions with owners:			
Dividend	–	–	–
Balance at 30 June 2018	8,494	45,776	54,270

The accompanying notes form an integral part of these financial statements.

Statement of Financial Position

as at 30 June 2018

Group	Note	Actual 2018 \$'000s	Budget 2018 (unaudited) \$'000s	Actual 2017 \$'000s
Non-current assets				
Property, plant and equipment	4	29,992	32,368	29,544
Investments	14	280	30	30
Intangible assets	5	9,393	9,838	9,800
		39,665	42,236	39,374
Current assets				
Cash and cash equivalents		960	1,523	6,773
Investment cash		24,000	21,000	16,000
Trade and other receivables	6	10,264	7,520	7,658
Derivative financial instruments		–	–	68
Inventories – scientific materials and consumables		1,079	910	869
		36,303	30,953	31,368
Current liabilities				
Trade and other payables	7	12,246	11,380	11,440
Employee benefits	8	3,451	3,620	3,222
Finance lease liabilities	9	67	–	234
Derivative financial instruments		11	–	–
Income tax payable	10	903	486	620
		16,678	15,486	15,516
Net current assets		19,625	15,467	15,852
Non-current liabilities				
Employee benefits	8	1,367	1,237	1,292
Finance lease liabilities	9	–	–	50
Deferred taxation	11	3,653	3,773	3,885
		5,020	5,010	5,227
Net assets		54,270	52,693	49,999
Equity				
Share capital	12	8,494	8,494	8,494
Retained earnings		45,776	44,199	41,505
Total equity		54,270	52,693	49,999

The Board of Directors of the Institute of Environmental Science and Research Limited authorised these financial statements for issue on 23 August 2018.

On behalf of the Board:



Denise Church QSO

Chair



Quentin Hix

Deputy Chair

Dated 23 August 2018

The accompanying notes form an integral part of these financial statements.

Statement of Cash Flows

for the year ended 30 June 2018

Group	Note	Actual 2018 \$'000s	Budget 2018 (unaudited) \$'000s	Actual 2017 \$'000s
Cash flows from/(used in) operating activities				
<i>Cash was provided from:</i>				
Customers and strategic science investment funding		73,880	79,714	78,821
Interest received		592	387	233
		74,472	80,101	79,054
<i>Cash was applied to:</i>				
Suppliers and employees		(65,369)	(68,076)	(63,037)
Interest paid		–	–	(8)
Income tax paid	10	(1,695)	(1,541)	(2,070)
		(67,064)	(69,617)	(65,115)
Net cash inflow from operating activities	13	7,408	10,484	13,939
Cash flows from/(used in) investing activities				
<i>Cash was provided from:</i>				
Proceeds from sale of property, plant and equipment		2	–	4
Term deposit maturities		24,000	–	10,000
		24,002	–	10,004
<i>Cash was applied to:</i>				
Purchase of property, plant and equipment		(3,226)	(5,184)	(2,542)
Purchase of intangible assets		(1,470)	(1,867)	(680)
Investments		(300)	–	–
Investment in term deposits		(32,000)	(21,000)	(26,000)
		(36,996)	(28,051)	(29,222)
Net cash outflow from investing activities		(12,994)	(28,051)	(19,218)
Cash flows from/(used in) financing activities				
<i>Cash was provided from/(applied to):</i>				
Repayment of finance lease liabilities		(227)	(265)	(312)
Net cash outflow from financing activities		(227)	(265)	(312)
Net decrease in cash held		(5,813)	(17,832)	(5,591)
Cash and cash equivalents at the beginning of the period		6,773	19,355	12,364
Cash and cash equivalents at the end of the period		960	1,523	6,773

The accompanying notes form an integral part of these financial statements.

Notes to the Financial Statements

1. Statement of significant accounting policies

Reporting entity

These financial statements of the Institute of Environmental Science and Research Limited and its subsidiaries ("ESR" and the "Group") are for the year ended 30 June 2018.

ESR is a Crown Entity incorporated and based in New Zealand. Its registered office is 34 Kenepuru Drive, Porirua.

ESR is a Crown Research Institute that provides specialist scientific services and research to the public health, food safety, security and justice systems, and the environmental sector.

Statement of compliance

The financial statements have been prepared in accordance with the requirements of the Crown Entities Act 2004, the Crown Research Institutes Act 1992, the Companies Act 1993 and the Financial Reporting Act 2013.

These financial statements have been prepared in accordance with Generally Accepted Accounting Practice in New Zealand (NZ GAAP). They comply with International Financial Reporting Standards (IFRS) and other New Zealand accounting standards and authoritative notices as appropriate for for-profit entities.

Basis of preparation

The financial statements are prepared on the basis of historical cost, except for financial instruments, certain leased assets and long service leave as identified in the specific accounting policies and accompanying notes.

The financial statements are presented in New Zealand dollars and all values are rounded to the nearest thousand dollars (\$000).

The budget and target figures presented in these financial statements are unaudited.

Changes in accounting policies

Accounting policies have been applied on a basis consistent with the prior year.

Critical accounting estimates and judgements

The preparation of financial statements requires judgements, estimates and assumptions that affect the application of policies and reported amounts of assets and liabilities, income and expenses. The estimates and associated assumptions are based on historical experience and various other factors that are believed to be reasonable under the circumstances. Actual results may differ from these estimates. The estimates and assumptions are reviewed on an on-going basis.

The judgements that have the most significant effect on amounts recognised in the financial statements are applied in the determination of revenue.

Revenue

The Group uses the stage of completion method in accounting for its fixed price contracts to deliver scientific services.

The use of the stage of completion method requires management to estimate the services performed to date as a proportion of the total services to be performed. The stage of completion is calculated and reviewed monthly, and significant variances are investigated to ensure that the stage of completion estimate is reasonable, in line with the overall project plan, estimated completion date and prior measurements of progress.

Principles of consolidation

Subsidiaries

The consolidated financial statements incorporate the assets and liabilities of all subsidiaries of ESR as at 30 June 2018 and the results of the operations of all subsidiaries for the year then ended.

Subsidiaries are those entities controlled, directly or indirectly, by the Parent. Subsidiaries are consolidated from the date on which control is transferred to ESR. They are de-consolidated from the date that control ceases.

The acquisition method of accounting is used to account for the acquisition of businesses by the Group. The cost of an acquisition is measured as the fair value of the assets given, equity instruments issued and liabilities incurred or assumed at the date of exchange. Identifiable assets acquired and liabilities and contingent liabilities assumed in a business combination are measured initially at their fair values at the acquisition date, irrespective of the extent of any non-controlling interest. The excess of the cost over the fair value of the Group's share of the identifiable net assets acquired is recorded as goodwill. If the cost of acquisition is less than the Group's share of the fair value of the identifiable net assets of the subsidiary acquired the difference is recognised directly in the profit or loss.

Associates

An associate is an entity over which the Group has significant influence. Significant influence is the power to participate in the financial and operating policy decisions of the investee, but is not control or joint control over those policies.

The Group's investments in its associates are accounted for using the equity method. Under the equity method, the investment in an associate is initially recognised at cost and subsequently adjusted to recognise the Group's share of changes in net assets of the associate since the acquisition date. Goodwill relating to the associate is included in the carrying amount of the investment and is not tested for impairment separately.

In applying the equity method of accounting, the Group's share of the post-acquisition profits or losses of its associated companies is recognised in profit or loss and its share of post-acquisition other comprehensive income is recognised in other comprehensive income. These post-acquisition movements and distributions received from the associated companies are adjusted against the carrying amount of the investment.

Unrealised gains on transactions between the Group and its associated companies are eliminated to the extent of the Group's interest in the associated companies. Unrealised losses are also eliminated unless the transaction provides evidence of an impairment of the asset transferred.

After application of the equity method, the Group determines whether it is necessary to recognise an impairment loss on its investment in its associates. At each reporting date, the Group determines whether there is objective evidence that the investment in the associate or joint venture is impaired. If there is such evidence, the Group calculates the amount of impairment as the difference between the recoverable amount of the associate and its carrying value, and then recognises the loss within the statement of profit or loss.

When the Group's share of losses in an associated company equals or exceeds its interest in the associated company, including any other unsecured non-current receivables, the Group does not recognise further losses, unless it has obligations or has made payments on behalf of the associated company.

Property, plant and equipment

Items of property, plant and equipment are initially recorded at cost and subsequently at cost less accumulated depreciation and impairment. The cost of property, plant and equipment includes the value of consideration given to acquire the assets and the value of other directly attributable costs that have been incurred in bringing the assets to the location and condition necessary for their intended use.

The carrying amounts of property, plant and equipment are reviewed at least annually to determine if there is any indication of impairment. Where an asset's recoverable amount is less than its carrying amount, it will be reported at its recoverable amount and an impairment loss will be recognised.

Losses resulting from impairment are reported in the statement of profit or loss and other comprehensive income.

Realised gains and losses arising from the disposal of property, plant and equipment are recognised in the profit or loss and other comprehensive income in the periods in which the transactions occur.

Depreciation is charged on a straight-line basis at rates calculated to allocate the cost of an item of property, plant and equipment, less any estimated residual value, over its estimated useful life, as follows:

Type of asset	Estimated useful life
Land	Not depreciated
Freehold buildings and building fit out	10 – 50 years
Leasehold improvements	10 years
Plant, equipment and vehicles	3 – 10 years
IT equipment and internal software	3 – 12 years

Intangible assets

Computer software

Items of computer software that do not comprise an integral part of the related hardware are treated as intangible assets with finite lives. Intangible assets with finite lives are recorded at cost, and subsequently recorded at cost less any accumulated amortisation and impairment losses. Amortisation is charged to the statement of profit or loss on a straight-line basis over the useful life of the asset (between 3 and 12 years).

Customer contracts

The intangible asset customer contracts represents the fair value of future revenue streams from customer contracts acquired under business combinations. Initial recognition of the intangible asset is stated at fair value. Subsequent to initial recognition, acquired intangible assets are stated at initially recognised amounts less accumulated amortisation and any impairment. Amortisation of acquired intangible assets is made according to the straight-line method over their estimated useful life, not exceeding ten years.

Research and development costs – internally generated intangible assets

Expenditure on research is expensed when it is incurred.

Development expenditure incurred on an individual project is capitalised if the process is technically and commercially feasible, future economic benefits are probable and ESR intends to and has sufficient resources to complete development and to use or sell the asset.

Any expenditure capitalised is amortised over three years from the point the asset is ready for use, which is the period of expected future sales from the related project.

Impairment of non-financial assets

Intangible assets that have an indefinite useful life or intangible assets not yet ready to use are not subject to amortisation and are tested annually for impairment.

Assets that are subject to depreciation and amortisation are reviewed for impairment whenever events or changes in circumstances indicate that the carrying amount may not be recoverable. An impairment loss is recognised for the amount by which the asset's carrying amount exceeds its recoverable amount. The recoverable amount is the higher of an asset's fair value less costs to sell and value in use. For the purposes of assessing impairment, assets are grouped at the lowest levels for which there are separately identifiable cash flows (cash-generating units).

Taxation

Current tax

Current tax is calculated with reference to the current period's taxable profit or loss calculated using tax rates and tax laws that have been enacted or substantially enacted by reporting date. Current tax for the current and prior periods is recognised as a liability (or asset) to the extent that it is unpaid (or refundable).

Deferred tax

Deferred tax is calculated 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 tax base for those items.

Deferred tax assets and liabilities are not recognised if the temporary differences giving rise to them from the initial recognition of assets and liabilities (other than as a result of a business combination) affects neither taxable income nor accounting profit.

Deferred tax assets are recognised for deductible temporary differences and unused tax losses only if it is probable that future taxable amounts will be available against which deductible temporary differences or unused tax losses and tax offsets can be utilised.

Deferred tax assets and liabilities are measured at the tax rates expected to apply when the assets are recovered or liabilities settled using tax rates and tax laws that have been enacted or substantially enacted by the reporting date.

Cash and cash equivalents

Cash means cash on hand, demand deposits and other highly liquid investments in which ESR has invested as part of its day-to-day cash management. The following definitions are used in the statement of cash flows:

- Investing activities are those activities relating to the acquisition, holding and disposal of fixed assets and investments.
- Financing activities are those activities that result in changes in the size and composition of the capital structure of ESR and this includes both equity and debt not falling within the definition of cash. Dividends paid in relation to the capital structure are included in financing activities.
- Operating activities are the principal revenue producing activities and other activities that are not investing or financing activities.

Investment cash

Investment cash represents cash held in bank deposits with original maturities of between 3 and 12 months. Investment cash movements are included in investing activities in the statement of cash flows.

Trade and other receivables

Trade receivables are recognised initially at fair value and subsequently measured at amortised cost using the effective interest rate method, less any provision for impairment.

Collectability of receivables is reviewed on an ongoing basis. A provision for doubtful debts is established when there is objective evidence that the Group will not be able to collect all amounts due according to the original terms of receivables. Bad debts are written off in the period in which they are identified.

Inventories

Stocks of consumables and work in progress are stated at the lower of cost and net realisable value. Cost is determined on a first in, first out basis.

Trade and other payables

Trade payables are obligations to pay for goods or services that have been acquired in the ordinary course of business from suppliers. Accounts payable are classified as current liabilities if payment is due within one year or less. If not, they are presented as non-current liabilities. Trade payables are recognised initially at fair value and subsequently at amortised cost using the effective interest rate method.

Employee benefits

Wages, salaries and annual leave

Liabilities for wages and salaries including annual leave that are expected to be settled within 12 months of the reporting date are recognised in respect of employees' services up to the reporting date and are measured at the amounts expected to be paid when the liabilities are settled.

Obligations for contributions to defined contribution retirement plans are recognised as an expense in the statement of profit or loss and other comprehensive income as they fall due.

Long service leave and retirement leave

Liabilities for long service and retirement leave are recognised as employee benefit liabilities and measured as the present value of expected future payments to be made in respect of services provided by employees up to the reporting date. Consideration is given to the expected future salary levels, experience of employee departures and periods of service. Expected future payments are discounted using market yields at the reporting date for government bonds with terms to maturity and currency that match, as closely as possible, the estimated future cash outflows.

Leases

Finance leases transfer to ESR, as lessee, substantially all the risks and rewards incidental to ownership of a leased asset. Initial recognition of a finance lease results in an asset and liability being recognised at amounts equal to the lower of the fair value of the leased asset or the present value of the minimum lease payments. Each lease payment is allocated between the liability and finance charges so as to achieve a constant rate of finance charge over the term of the lease. Property, plant and equipment acquired under a finance lease are depreciated over the shorter of the useful life and lease term of the asset.

Leases in which a significant portion of the risks and rewards of ownership are retained by the lessor are classified as operating leases. Payments made under operating leases (net of any incentives received from the lessor) are charged to the statement of profit or loss and other comprehensive income on a straight-line basis over the period of the lease.

Share capital

Ordinary shares are classified as equity. Incremental costs directly attributable to the issue of new shares or options are shown as appropriate in equity as a deduction, net of tax, from the proceeds.

Revenue**Sales of goods and services**

Revenue is earned by ESR in exchange for the provision of outputs (services) to third parties.

Revenue from the supply of services is measured at the fair value of consideration received. Revenue from the supply of services is recognised in the accounting period in which the services are rendered, by reference to the stage of completion of the specific transaction assessed on the basis of the actual service provided as a proportion of the total services to be provided.

Any revenue for which services have not been supplied as at the reporting date but for which payment has been received is deferred within the statement of financial position as revenue in advance.

Strategic science investment funding

ESR receives strategic science investment funding from the government in order to perform scientific research activities. Strategic science investment funding is treated as a government grant and recognised at fair value in the statement of profit or loss and other comprehensive income when the requirements under the funding agreement have been met.

Interest income

Interest income is recognised in the statement of profit or loss and other comprehensive income on a time proportion basis, using the effective interest rate method.

Foreign currency

Items included in the financial statements of each of the Group's entities are measured using the currency of the primary economic environment in which the entity operates. The Group financial statements are presented in New Zealand dollars, which is ESR's functional currency.

Foreign currency transactions are recorded at the foreign exchange rates in effect at the dates of the transactions. Monetary assets and monetary liabilities denominated in foreign currencies are translated at the rates of exchange ruling at the end of each reporting period.

Goods and services tax

Items in the statement of profit or loss and other comprehensive income and statement of cash flows are disclosed net of Goods and Services Tax (GST). All items in the statement of financial position are stated net of GST with the exception of receivables and payables, which include GST invoiced.

Dividends

A provision is made for the amount of any dividend declared on or before the end of the financial year but not distributed at balance date.

Financial instruments

The designation of financial assets and financial liabilities by ESR into instrument categories is determined by the business purposes of the financial instruments, policies and practices of management, the relationship with other instruments and the reporting costs and benefits associated with each designation. The designations applied by ESR are reflected in the financial statements.

Financial assets

The Group classifies its financial assets as loans and receivables and at fair value through profit and loss. Management determines the classification of its financial assets at initial recognition.

Loans and receivables are non-derivative financial assets with fixed or determinable payments that are not quoted in an active market. They are included in current assets, except for maturities greater than 12 months after the reporting date which are classified as non-current assets. ESR's loans and receivables comprise trade and other receivables, investment cash and cash and cash equivalents in the statement of financial position.

Regular purchases and sales of financial assets are recognised on the trade-date – the date on which the Group commits to purchase or sell the asset. Financial assets are derecognised when the rights to receive cash flows from the investments have expired or have been transferred and the Group has transferred substantially all risks and rewards of ownership. Loans and receivables are carried at amortised cost using the effective interest rate method.

The Group assesses at each reporting date whether there is objective evidence that a financial asset or a group of financial assets is impaired. A financial asset or group of financial assets is impaired and the impairment losses are incurred only if there is objective evidence of impairment as the result of one or more events that occurred after the initial recognition of the asset (a 'loss event') and that loss event (or events) has an impact on the estimated future cash flows of the financial asset or group of financial assets that can be reliably estimated. Evidence of impairment may include indications that the debtor or group of debtors is experiencing significant financial difficulty, default or delinquency in interest or principal payments, the probability that they will enter bankruptcy or other financial reorganisation, and where observable data indicates that there is a measurable decrease in the estimated future cash flows, such as changes in arrears or economic conditions that correlate with defaults.

Financial liabilities

Financial liabilities held by ESR include trade and other payables, employee benefits and finance lease liabilities.

Such financial liabilities are recognised initially at fair value less transaction costs and subsequently measured at amortised cost using the effective interest rate method.

Derivatives

Derivative financial instruments are recognised both initially and subsequently at fair value. They are reported as either assets or liabilities depending on whether the derivative is in a net gain or net loss position. ESR does not use hedge accounting and as such derivatives are classified as held-for-trading financial instruments with fair value gains or losses recognised in the statement of profit or loss and other comprehensive income. Such derivatives are entered into for risk management purposes.

Adoption status of relevant new financial reporting standards and interpretations

The Group has elected not to early adopt any of the new standards and amendments to existing standards which have been issued as at 30 June 2018 but that are not yet effective. It is anticipated that these standards will not significantly impact the financial statements of the Group once adopted, with the exception of NZ IFRS 15 and NZ IFRS 16.

NZ IFRS 9 Financial Instruments (effective for annual periods beginning on or after 1 January 2018)

NZ IFRS 9 Financial Instruments replaces NZ IAS 39 Financial Instruments: Recognition and Measurement and all previous versions of NZ IFRS 9.

NZ IFRS 9 addresses the classification, measurement and recognition of financial assets and liabilities, introduces new rules for hedge accounting and a new impairment model for financial assets. Except for hedge accounting, retrospective application is required but providing comparative information is not compulsory. For hedge accounting, the requirements are generally applied prospectively, with some limited exceptions.

The Group will adopt the new standard on the required effective date and will not restate comparative information. Overall, the Group expects no significant impact on its statement of financial position and equity.

NZ IFRS 15, Revenue from Contracts with Customers (effective for annual periods beginning on or after 1 January 2018)

NZ IFRS 15 addresses recognition of revenue from contracts with customers, replacing the revenue recognition guidance in NZ IAS 18 Revenue and NZ IAS 11 Construction Contracts and is applicable to all entities with revenue. It sets out a 5 step model for revenue recognition to depict the transfer of promised goods or services to customers in an amount that reflects the consideration to which the entity expects to be entitled in exchange for those goods or services. The standard permits either a full retrospective or a modified retrospective approach for adoption.

The Group will adopt the new standard on the required effective date and plans to use the modified retrospective approach.

While the Group has yet to fully quantify the impact of NZ IFRS 15, work done to date indicates that the most significant impact of the new standard will be on the timing of recognition of revenue from software licence sales. Revenue from licence sales will be recognised earlier than under NZ IAS 18, at the point at which the Group provides customers with access to the software licence.

NZ IFRS 16, Leases (effective for annual periods beginning on or after 1 January 2019)

NZ IFRS 16 introduces a single lessee accounting model and requires a lessee to recognise right-of-use assets and liabilities for all leases with a term of more than 12 months, unless the underlying asset is of low value. The Group has yet to assess the full impact of NZ IFRS 16. The Group will apply this standard from 1 July 2019.

2. Other expenses

Group	Note	2018 \$'000s	2017 \$'000s
Fees paid to PricewaterhouseCoopers for:			
– the audit of the statutory financial statements		113	112
– the SHIVERS Project Uniform Guidance audit		29	28
Total audit related fees paid to the auditors		142	140
– taxation compliance and advice		40	53
– cyber security training		36	–
Total fees paid to auditors		218	193
Directors' fees	16	193	202
Directors' expenses		30	55
Bad debts written off		8	–
Communication costs (including network charges)		600	604
IT systems maintenance and licence costs		1,606	1,376
Legal and consultancy fees		2,496	1,791
Impairment of receivables (loans and advances)		11	–
Fair value loss/(gain) on forward exchange contract		79	66
Office and administration		1,421	1,561
Occupancy and insurance		2,711	2,777
Rental and operating lease costs		665	689
Travel		2,066	2,121
Restructuring expense		154	–
Outsourced costs		1,885	2,083
Other operating costs		268	326
Other expenses		14,411	13,844

Given the nature of ESR's principal business activities, research comprises part of ESR's everyday business operations. As such, expenses relating to research are not separately identified. The cost of research to ESR is distributed between the relevant expense items, for example employee benefits and scientific materials used.

3. Taxation

Group	Note	2018 \$'000s	2017 \$'000s
The taxation charge has been calculated as follows:			
Profit/(loss) before income tax expense		6,019	7,081
Prima facie taxation at 28%		1,685	1,983
<i>Plus taxation effect of:</i>			
Net prior years under/(over) estimation		(1)	(1)
Non-deductible/(assessable) items		64	90
Tax/(Credit) expense for the year		1,748	2,072
<i>The tax expense for the year is represented by:</i>			
Current taxation	10	1,992	2,000
Deferred taxation	11	(244)	72
		1,748	2,072

4. Property, plant and equipment

Group	Freehold land \$'000s	Buildings and leasehold improvements \$'000s	IT equipment \$'000s	Plant, equipment and vehicles \$'000s	Assets under construction \$'000s	Total \$'000s
At 1 July 2016						
Cost	476	30,278	7,935	33,343	1,101	73,133
Accumulated depreciation	–	(8,620)	(6,463)	(27,266)	–	(42,349)
Net book value at the beginning of the year	476	21,658	1,472	6,077	1,101	30,784
Year ended 30 June 2017						
Net book value at the beginning of the year	476	21,658	1,472	6,077	1,101	30,784
Additions	–	338	657	1,548	40	2,583
Transfers from assets under construction	–	883	–	67	(950)	–
Reclassification to intangible assets	–	–	–	–	(151)	(151)
Disposals	–	–	–	(71)	–	(71)
Depreciation for the year	–	(988)	(806)	(1,807)	–	(3,601)
Net book value at the end of the year	476	21,891	1,323	5,814	40	29,544
At 30 June 2017						
Cost	476	31,499	7,583	34,533	40	74,131
Accumulated depreciation	–	(9,608)	(6,260)	(28,719)	–	(44,587)
Net book value at the end of the year	476	21,891	1,323	5,814	40	29,544
Year ended 30 June 2018						
Net book value at the beginning of the year	476	21,891	1,323	5,814	40	29,544
Additions	–	317	1,260	2,194	350	4,121
Transfers from assets under construction	–	39	–	–	(39)	–
Disposals	–	–	(2)	(10)	–	(12)
Depreciation for the year	–	(1,020)	(977)	(1,664)	–	(3,661)
Net book value at the end of the year	476	21,227	1,604	6,334	351	29,992
At 30 June 2018						
Cost	476	31,855	8,015	35,139	351	75,836
Accumulated depreciation	–	(10,628)	(6,411)	(28,805)	–	(45,844)
Net book value at the end of the year	476	21,227	1,604	6,334	351	29,992

IT equipment recognised under finance leases (where ESR is a lessee) included in the above table, has the following values.

Group	2018 \$'000s	2017 \$'000s
Cost – capitalised finance lease assets	456	859
Accumulated depreciation	(402)	(589)
Net book value at the end of the year	54	270

ESR does not have any property, plant and equipment used as security for liabilities.

Restriction on Title

In relation to the transfer of land owned by ESR, shareholding ministers shall have regard to the principles of the Treaty of Waitangi in accordance with section 10 of the Crown Research Institutes Act 1992.

Properties owned by ESR in Christchurch, Wellington and Auckland have caveats on the land as required by section 31 of the Crown Research Institutes Act 1992, which maintains the general provisions of the Public Works Act 1981. ESR complies with section 31 of the Crown Research Institutes Act 1992.

5. Intangible assets

Group	Computer software – externally purchased \$'000s	Computer software – internally generated \$'000s	Customer contracts \$'000s	Assets under construction \$'000s	Total \$'000s
At 1 July 2016					
Cost	8,284	13,465	1,338	371	23,458
Accumulated amortisation	(6,729)	(4,663)	(1,022)	–	(12,414)
Net book value at the end of the year	1,555	8,802	316	371	11,044
Year ended 30 June 2017					
Net book value at the beginning of the year	1,555	8,802	316	371	11,044
Additions	226	57	–	246	529
Transfers from assets under construction	–	314	–	(314)	–
Reclassification from property, plant and equipment	–	–	–	151	151
Amortisation for the year	(566)	(1,135)	(223)	–	(1,924)
Net book value at the end of the year	1,215	8,038	93	454	9,800
At 30 June 2017					
Cost	8,503	13,836	1,338	454	24,131
Accumulated amortisation and impairment losses	(7,288)	(5,798)	(1,245)	–	(14,331)
Net book value at the end of the year	1,215	8,038	93	454	9,800
Year ended 30 June 2018					
Net book value at the beginning of the year	1,215	8,038	93	454	9,800
Additions	568	15	–	887	1,470
Transfers from assets under construction	17	383	–	(400)	–
Amortisation for the year	(508)	(1,276)	(93)	–	(1,877)
Net Book Value at the End of the Year	1,292	7,160	–	941	9,393
At 30 June 2018					
Cost	9,078	14,234	1,338	941	25,591
Accumulated amortisation and impairment losses	(7,786)	(7,074)	(1,338)	–	(16,198)
Net book value at the end of the year	1,292	7,160	–	941	9,393

ESR does not have any intangible assets whose title is restricted or used as security for liabilities.

Intangible assets include ESR's laboratory operating system with a net book value of \$6,784,000 (2017: \$7,700,000). The laboratory operating system has an estimated remaining useful life of 6 years.

6. Trade and other receivables

Group	2018 \$'000s	2017 \$'000s
Trade debtors	8,792	6,648
Provision for doubtful debts	(79)	(68)
	8,713	6,580
Prepayments	1,551	1,078
	10,264	7,658

As at 30 June 2018, trade receivables of \$1,218,000 (2017: \$204,000) were past due but not impaired. These relate to a number of customers for whom there is no recent history of default. The ageing analysis of these trade receivables is as follows:

Past due 1 – 30 days	781	86
Past due 31 – 60 days	102	29
Past due > 61 days	335	89
	1,218	204

7. Trade and other payables

Group	2018 \$'000s	2017 \$'000s
Accrued expenses	2,133	2,621
GST payable	311	12
Revenue in advance	4,599	4,591
Trade payables	5,203	4,216
	12,246	11,440

8. Employee benefits

Group	2018 \$'000s	2017 \$'000s
Annual leave accrual	3,160	2,972
Service leave accrual	274	237
Other	17	13
Current liabilities	3,451	3,222
Service leave accrual	1,290	1,220
Retirement leave accrual	77	72
Non-current liabilities	1,367	1,292

9. Finance lease liabilities

Future minimum lease payments are as follows:

Group	2018 \$'000s	2017 \$'000s
Not later than one year	70	244
Later than one year and not later than five years	–	52
Total minimum lease payments	70	296
Future finance charges on finance leases	(3)	(12)
Present value of finance lease liabilities	67	284

The finance leases relate to IT equipment. Upon termination of the initial lease period, ESR can either choose to extend the term further, or return the leased assets to the lessor. There is no option to purchase the leased assets upon termination of the lease.

The present value of finance lease liabilities are as follows:

Group	2018 \$'000s	2017 \$'000s
Not later than one year	67	234
Later than one year and not later than five years	–	50
	67	284

10. Income tax payable

Group	2018 \$'000s	2017 \$'000s
Balance at the beginning of the year	620	730
Current year charge	1,992	2,000
Prior period adjustment	(14)	(40)
Provisional taxation payments	(1,695)	(2,070)
Balance at the end of the year	903	620

11. Deferred taxation

Deferred tax liabilities/(assets) are attributed to the following:

Group	2018 \$'000s	2017 \$'000s
Balance at the beginning of the year	3,885	3,773
Prior period adjustment	12	40
Charge to statement of profit or loss and other comprehensive income	(244)	72
Balance at the end of the year	3,653	3,885

	Accelerated tax depreciation \$'000s	Employee benefits \$'000s	Provisions and other items \$'000s	Total \$'000s
Year ended 30 June 2017				
Balance at the beginning of the year	5,128	(1,189)	(166)	3,773
Over provision in prior years	–	40	–	40
Current year charge/(credit) to statement of profit or loss and other comprehensive income	148	(166)	90	72
Balance at the end of the year	5,276	(1,315)	(76)	3,885
Year ended 30 June 2018				
Balance at the beginning of the year	5,276	(1,315)	(76)	3,885
Over provision in prior years	–	12	–	12
Current year charge/(credit) to statement of profit or loss and other comprehensive income	(167)	(133)	56	(244)
Balance at the end of the year	5,109	(1,436)	(20)	3,653

There are no unrecognised deferred tax assets or liabilities.

12. Equity

Share capital

Group	2018 \$'000s	2017 \$'000s
8,494,000 Ordinary \$1 Shares (issued and fully paid)	8,494	8,494

All ordinary shares rank equally with one vote attached to each fully paid ordinary share.
No dividends were proposed or declared for the 30 June 2018 year (2017: nil).

13. Reconciliation of profit/(loss) after taxation to cash flows from operating activities

Group	Note	2018 \$'000s	2017 \$'000s
Profit for the year after taxation		4,271	5,009
Non-cash items:			
Depreciation and amortisation expense	4, 5	5,538	5,525
Equity accounted earnings from associate company investment		50	–
Bad debts written off	2	8	–
Increase/(decrease) in provision for doubtful debts	6	11	–
(Decrease)/increase in deferred tax liability	11	(232)	112
Fair value loss/(gain) on derivative financial instruments	2	79	66
		5,454	5,703
Changes in working capital:			
(Increase)/decrease in trade and other receivables		(2,625)	230
(Increase)/decrease in inventories		(210)	6
Increase in trade and other payables		806	2,441
Increase/(decrease) in income tax payable		283	(110)
Increase in employment benefits		304	395
		(1,442)	2,962
Items classified as investing and financing activities:			
(Profit)/loss on disposal of property, plant and equipment		11	(1)
(Increase)/decrease in trade payables related to property, plant and equipment		(896)	252
Finance charge on leases		10	14
		(875)	265
Net cash inflow from operating activities		7,408	13,939

14. Investments**Subsidiary companies**

ESR has two wholly owned subsidiary companies:

Name	Balance Date	Country of Incorporation
ESR Limited	30 June	New Zealand
STRMIX Limited	30 June	New Zealand

ESR Limited has remained non-trading during the period. At balance date the investment in the subsidiary had a nil carrying value.

STRMIX Limited was incorporated in September 2017 and did not trade during the period. At balance date the investment in the subsidiary had a nil carrying value.

Investments

ESR holds 18 shares in Kiwi Innovation Network Limited and the investment has a carrying value of \$30,000 (2017: \$30,000)

ESR acquired an interest in AuramerBio Limited during the period. AuramerBio Limited is a start-up company focused on the development of DNA aptamer sensors.

AuramerBio Limited is classified as an associate, with ESR holding 18% of the shares of the company.

As at 30 June 2018, AuramerBio Limited has total assets of \$780,000 and net assets of \$275,000. ESR's share of the post-acquisition losses of AuramerBio Ltd was \$50,000, reducing the carrying value of this investment to \$250,000 at 30 June 2018.

15. Commitments

Capital commitments

Group	2018 \$'000s	2017 \$'000s
Property, plant and equipment	417	1,193
Intangible assets – software	–	73
Total capital commitments	417	1,266

Operating lease commitments

The future aggregate minimum lease payments under non-cancellable operating leases are as follows:

Group	2018 \$'000s	2017 \$'000s
Not later than one year	22	33
Later than one year and not later than five years	69	54
Total operating lease commitments	91	87

ESR leases land, buildings, equipment and vehicles. There are renewal options in respect of the land and building leases. There are no renewal options or options to purchase in respect of vehicles held under operating leases.

ESR has a number of standard operational agreements for the purchase of materials and consumables that have both fixed and variable components, some of which extend beyond one year.

16. Related party transactions and key management personnel

Related party transactions

ESR is a wholly owned entity of the Crown. ESR receives Strategic Science Investment Funding from the Government and enters into transactions with other Crown entities on a commercial basis. In the year ended 30 June 2018 revenue from commercial transactions with Crown entities amounted to 61% of operating revenue (30 June 2017: 63%).

Related parties include the entities disclosed in note 14. There have been no transactions with these related parties in the year ended 30 June 2018 (30 June 2017: nil).

The following transactions were carried out with related parties:

- Fees paid to Directors during the year were \$192,691 (30 June 2017: \$201,846). There were no Directors' fees payable at balance date (30 June 2017: nil).

No provision has been required, nor any expense recognised, for impairment of receivables from related parties.

Key management personnel compensation

Key management personnel comprise the Chief Executive Officer, members of the Senior Leadership Team and the Directors. Key management personnel compensation is disclosed below.

Group	2018 \$'000s	2017 \$'000s
Salaries and other short-term employee benefits	2,180	1,950
Termination benefits	36	–
Other long-term employee benefits	2	16
Directors' fees	193	202
Total key management personnel compensation	2,411	2,168

17. Financial instruments by category

Group	Loans and receivables \$'000s	Fair value through profit or loss \$'000s	Total \$'000s
30 June 2017			
Assets as per balance sheet:			
Trade and other receivables excluding prepayments	6,580	–	6,580
Derivative financial instruments	–	68	68
Cash and cash equivalents	6,773	–	6,773
Investment cash	16,000		16,000
Total	29,353	68	29,421

	Financial liabilities at amortised cost \$'000s	Fair value through profit or loss \$'000s	Total \$'000s
Liabilities as per balance sheet:			
Finance lease liabilities	284	–	284
Employee benefits	4,514	–	4,514
Trade payables and accrued expenses	6,837	–	6,837
Total	11,635	–	11,635

	Loans and receivables \$'000s	Fair value through profit or loss \$'000s	Total \$'000s
30 June 2018			
Assets as per balance sheet			
Trade and other receivables excluding prepayments	6 8,713	–	8,713
Cash and cash equivalents	960	–	960
Investment cash	24,000	–	24,000
Total	33,673	–	33,673
Liabilities as per balance sheet			
Finance lease liabilities	9 67	–	67
Employee benefits	4,818	–	4,818
Derivative financial instruments	–	11	11
Trade payables and accrued expenses	7 7,336	–	7,336
Total	12,221	11	12,232

18. Financial risk management

ESR's activities are exposed to a variety of financial risks: market risk (including cash flow and fair value interest-rate risk), credit risk and liquidity risk. ESR's overall risk management programme focuses on the unpredictability of financial markets and seeks to minimise potential adverse effects on ESR's financial performance. The policies approved and financial instruments being utilised at balance date are outlined below.

a) Market risk

In accordance with its Treasury Management Policy, ESR uses derivative financial instruments to economically hedge its exposure to foreign exchange risks from its operational, financing and investment activities. These derivatives are classified at fair value through profit or loss, and gains and losses are recognised in profit or loss in the statement of profit or loss and other comprehensive income.

i) Foreign exchange risk

Foreign exchange risk occurs as a result of transactions denominated in a currency other than ESR's functional currency of New Zealand dollars. Currencies commonly transacted in, and giving rise to foreign exchange risk include the United States dollar, Australian dollar, euro and the pound sterling. ESR is subject to foreign currency risk through its trade receivables and trade payables balances.

ESR is required by its Treasury Management Policy to hedge net foreign currency exposures equivalent to greater than New Zealand dollar \$100,000 using approved treasury instruments.

ESR held three forward exchange contracts with notional principal amounts totalling US \$1,000,000 at 30 June 2018 (30 June 2017: one contract of US \$363,000).

The carrying amounts of the Group's trade and other receivables denominated in foreign currencies are:

	2018 \$'000s	2017 \$'000s
US dollar	1,886	1,478
Australian dollar	13	5
Pound sterling	4	25
Euro	–	110

The carrying amounts of the Group's trade and other payables denominated in foreign currencies are:

	2018 \$'000s	2017 \$'000s
Australian dollar	328	28
US dollar	21	134
Euro	7	36
Pound sterling	5	14
Others	–	4

ii) Interest rate risk

As at reporting date, ESR is subject to interest rate risk through the holding of cash and cash equivalents and investment cash. ESR uses a mixture of call and short-term deposit investment accounts to hold excess funds. Available interest rates are monitored to ensure the best return on cash.

- proportional foreign exchange rate movement of -10% (depreciation of New Zealand dollar) and +10% (appreciation of New Zealand dollar) against foreign currencies; and
- a parallel shift of +1%/-1% in market interest rates in New Zealand.

If these movements were to occur (all other variables held constant), the impact on ESR's reported net profit after tax for the year ended 30 June 2018 would be:

- foreign currency \$528,000 (30 June 2017: \$683,000)
- interest rates \$144,000 (30 June 2017: \$65,000)

b) Credit risk

Credit risk refers to the risk that a counterparty will default on its contractual obligations, resulting in financial loss to ESR. The financial instruments which expose ESR to credit risk are, principally, cash and cash equivalents, investment cash and trade receivables.

Bank balances and short-term investments (comprising cash and cash equivalents and investment cash) are held with New Zealand registered banks in accordance with ESR's Treasury Management Policy.

The majority of high value trade receivables comprise government entities and therefore the potential risk of default is low. ESR has a Contract Management Policy which requires assessment of credit worthiness of potential clients, where the value of the contract is material as defined in the policy.

A provision for doubtful debts is maintained in respect of trade receivables and this is reassessed on a regular basis. No collateral is held by ESR in respect of cash and cash equivalents, investment cash and trade receivables as at 30 June 2018 (30 June 2017: nil).

The carrying amount of financial assets recognised in the statement of financial position best represents ESR's maximum exposure to credit risk at the reporting date.

As at 30 June 2018 the trade receivables balance included \$4,962,000 (30 June 2017: \$2,079,000) owed by entities within, or owned by, the New Zealand Government. It is not believed that there is any material risk of loss with these receivables.

c) Liquidity risk

Prudent liquidity risk management implies the availability of funding through adequate levels of committed credit facilities. Liquidity risk is monitored through the forecasting of cash flows, and ensuring that the committed credit lines in place remain adequate for requirements.

The contractual undiscounted maturity analysis of financial liabilities is presented below:

Group	2018					2017				
	Carrying value \$'000s	Less than 1 year \$'000s	1-2 years \$'000s	2-5 years \$'000s	Greater than 5 years \$'000s	Carrying value \$'000s	Less than 1 year \$'000s	1-2 years \$'000s	2-5 years \$'000s	Greater than 5 years \$'000s
Trade payables	7,336	7,336	–	–	–	6,837	6,837	–	–	–
Employee benefits	4,818	3,451	91	39	1,237	4,514	3,222	68	37	1,187
Finance lease liabilities	67	67	–	–	–	284	234	50	–	–
	12,221	10,854	91	39	1,237	11,635	10,293	118	37	1,187

d) Fair values

The carrying value of financial assets and liabilities recorded in the financial statements approximate their fair values.

Fair value is generally based on the contracted amount payable/receivable of financial assets and financial liabilities, being the amount for which the financial instrument is to be exchanged. Fair value includes the impact of any assessed impairment of the financial instruments – refer to the statement of significant accounting policies for details of each financial instrument and their recognition criteria.

e) Capital risk management

ESR's objectives when managing capital are to maintain financial stability, achieve sustainable growth and to realise its strategic goals and targets, all within the risk appetite of its shareholders and management.

In line with Government requirements, ESR monitors its capital structure through the return on equity and gearing ratios. Government provides ESR with guidelines with the expectation that an appropriate average return is achieved over time, rather than requiring that ESR meet the specified targets annually.

Each year ESR internally sets return on equity and gearing ratio targets, bearing in mind the overall results expected by Government. The ratios are reported in the Statement of Corporate Intent.

The return on equity and gearing ratios as at 30 June 2018, and 30 June 2017 were as follows, along with the relevant annual targets set by ESR.

Group	2018 \$'000s	2017 \$'000s
Return on equity ratio		
Profit/(loss) for the year	4,271	5,009
Average equity	52,135	47,495
Actual ratio	8.2%	10.5%
Target ratio	7.7%	5.7%
Gearing ratio		
Net debt		
Finance lease liabilities – current	67	234
Finance lease liabilities – non current	–	50
	67	284
Equity	54,270	49,999
Actual ratio	0.1%	0.6%
Target ratio	0.0%	0.4%

19. Contingent liabilities

The directors are satisfied that there are no claims outstanding that would have a material impact on ESR's financial position as at 30 June 2018 (30 June 2017: Nil).

20. Subsequent events

There were no events subsequent to reporting date that require disclosure in the financial statements.

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Chris Ussher of PricewaterhouseCoopers on behalf of the Auditor-General

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SOLICITOR

Buddle Findlay

Presented to the House of Representatives pursuant to Section 44 of the Public Finance Act 1989.

The Institute of Environmental Science and Research Limited (ESR) is a Crown Research Institute. It was incorporated in July 1992 and is wholly owned by the New Zealand Government. The two Shareholding Ministers appoint a Board of Directors to govern the organisation. ESR has science centres in Auckland, Wellington (Porirua and Wallaceville) and Christchurch.

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