**Groundwater science to support climate change adaptation**

New Zealand's groundwater resources play a crucial role in supporting environmental health, drinking water supplies, recreational and cultural activities (80% of river flows are sustained through groundwater discharges), and economic development (through irrigation). This role is set to become even more important as climate change and population growth place increased pressure on our freshwater resources. Groundwater is more resilient than surface water to climate variability, making it a valuable asset in ensuring water availability. Aquifers can store water underground following high rainfall events, release water during drier periods, and limit evaporative losses. Nonetheless, the potential effects of climate change on groundwater are not yet well understood.

To help close this knowledge gap, our SSIF-funded Groundwater programme completed a series of projects that investigated the potential impacts of climate change on groundwater resources. Several strategic management tools and approaches were developed to help water resource managers in their decision-making around how best to manage groundwater to adapt to climate change. These projects were developed in collaboration with key stakeholders and end-users and were supported by aligned research funded by the Endeavour Fund (e.g., NZSeaRise Programme), Deep South National Science Challenge, MPI and various commercial projects.

1. **Climate change-induced impacts on the replenishment of New Zealand aquifers**
   We successfully trialled a new methodology to assess the effects of climate change on the replenishment (or recharge) of aquifers by rainfall in two contrasting case study regions – Hawke's Bay and Otago. The approach was developed in collaboration with NIWA and the respective regional councils, and can be replicated nationwide. The project provided insights into the potential effects of climate change on groundwater resources, including groundwater depletion and occurrences of groundwater inundation. It also delivered a national review of current knowledge of the potential impacts of climate change and relevant information for resource managers and policy makers to start implementing adaptation actions.

2. **How rising sea levels impact coastal urban aquifers**
   Coastal communities and infrastructure are becoming increasingly exposed to direct inundation during storms. Less obvious are the largely unseen and poorly understood impacts of rising sea levels on groundwater. We investigated these impacts on South Dunedin's shallow coastal aquifer in collaboration with Otago Regional Council (ORC) and Dunedin City Council (DCC). A series of groundwater maps was produced to assess the spatial reach and the impacts of sea level rise on South Dunedin Aquifer and the exposure of communities. We also developed a numerical groundwater model to explore the viability of mitigation measures and other forms of adaptation. These outputs have been used by DCC and ORC to develop a science-informed South Dunedin Future's Plan in conjunction with the local community. The framework developed by this project can be used by other New Zealand coastal cities and towns built on shallow aquifers to help build their resilience.

3. **Potential for contamination of drinking water supplies after extreme weather events**
   Another project focused on the potential contamination of groundwater after extreme weather events, particularly high rainfall intensity events, such as those associated with the 2016 contamination of Havelock North's drinking water and more recently, Cyclone Gabrielle. With climate change, these types of groundwater contamination are expected to increase, compromising the security of drinking water supplies. Our project investigated community drinking water bores in aquifers that supply several major cities (Hastings, Napier, Christchurch and Lower Hutt) to identify potential fast flow paths that could pose an increased

risk of pathogen contamination, especially during high rainfall intensity events. The enhanced understandings produced by this project have supported local governments to reinforce the security of their community drinking water supplies.

4. **Weaving mātauranga Māori and western science for more impactful adaptation actions**
We initiated new collaborations with local iwi, hapū and communities of the North Kaipara Harbour to help embed local and indigenous knowledge into the design and implementation of our groundwater research in the region. Pressures from climate change are already affecting the communities and infrastructure in this area and are projected to intensify with sea level rise and more extreme rainfall events. Our interactions with the local iwi, hapū and communities have already brought out some mutual understandings that inform our research on how mātauranga Māori and Te Ao Māori can be weaved with western science to develop more efficient adaptation actions.

Collectively, these different research projects have produced a series of tools, understandings and approaches that complement each other and support water resource managers, iwi and communities to implement more effective adaptation actions.