NEW ZEALAND'S WATER SYSTEMS *particularly vulnerable to climate change*

Interdisciplinary collaboration to help enable New Zealanders to adapt, manage risk, and thrive in a changing climate.

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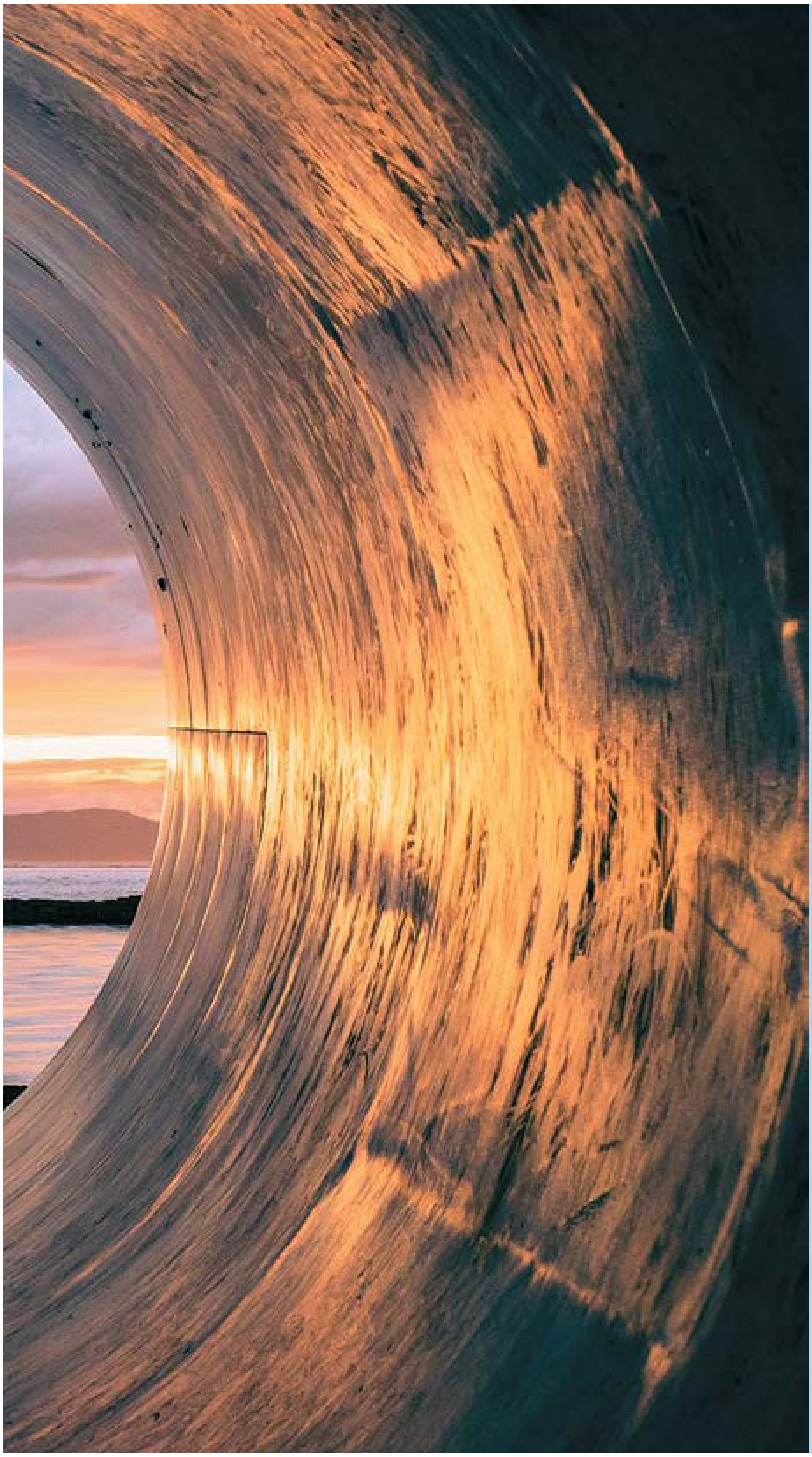

As the end of our hottest summer on record draws to a close it seems a good time to reflect on how climate change may affect New Zealand.

This article outlines the findings of research commissioned by the Deep South National Science Challenge - a major interdisciplinary collaboration designed to help enable New Zealanders to adapt, manage risk, and thrive in a changing climate.

THIS WIDE SPREAD OF KNOWLEDGE ALLOWED THE RESEARCH TO ADDRESS DIFFERENT ASPECTS OF THE ISSUE – FROM THE CLIMATE SCIENCE, TO THE PRACTICALITIES OF MANAGING INFRASTRUCTURE, ***to the extent our decision making frameworks are fit-for-purpose, to learning from international perspectives on adaptation.***

THE aim of the project was to provide an analysis of our current knowledge regarding stormwater, wastewater, and climate change, and to identify the key areas that we should focus on now to help adapt our stormwater and wastewater systems for a changing climate. The research was conducted in the latter half of 2017 and the methodology was a series of workshops with key actors and agencies. These included academia, Crown Research Institutes, the different tiers of government, water service providers, industry bodies, and a range of expert consultants. This wide spread of knowledge allowed the research to address different aspects of the issue – from the climate science, to the practicalities of managing infrastructure, to the extent our decision making frameworks are fit-for-purpose, to learning from international perspectives on adaptation.

The key findings are:

- We know climate change is happening and that stormwater and wastewater systems are vulnerable, but there are significant knowledge gaps. In short, we do not yet know how these impacts will unfold over varying places, timescales, and speeds.
- The projected changes will inevitably challenge existing design and performance parameters. Most notably with regard to rainfall intensity and distribution, drought severity, and coastal inundation.
- We do not yet have good information on the cascading disruptive effects of infrastructure failure on health, transport, culturally significant locations, evacuation routes, recreational and commercial activities, waterway ecology, and more.
- We need to adapt both our land uses and the ways we make decisions; in particular, we need to manage uncertainty and complexity better over multiple scales and times.

The results have significant implications for central and local government, those concerned with our stormwater and wastewater infrastructure, and notably, the planning sector. This is not just in terms of better managing new development, or retrofitting the urban environment to be more water sensitive, but also with regard to working across different scales and agencies to help manage such a complex risk better. More generally, it emphasises that in order to increase the resilience of our water systems those concerned with infrastructure provision need to make effective decisions under conditions of uncertainty – even if we greatly expand our evidence base, there will always be gaps in our knowledge concerning aspects such as extremes and the speed of change.

The scale of the sector is significant: stormwater infrastructure has a replacement value of around $8.6 billion (Castalia, 2014) whereas the wastewater network has a replacement value of $15.8 billion (LGNZ, 2015). The assets include 24,000 kilometres of public wastewater network, more than 3,000 treatment plants, and over 17,000 kilometres of stormwater network. These figures should be treated with significant caution however. The data covers replacement to current specifications, not those that may be required to maintain standards of operation in a changing climate where extremes are more commonplace. Other information gaps were identified. For example, age

and deterioration of assets is an issue, but there is no consistency of reporting (Water New Zealand, 2015) making national understanding and assessment difficult.

Overall, the picture is one of increasing exposure. Approximately 6.6% of our total population and $52 billion worth of our built assets are located within a particularly exposed area (Bell et al., 2015; Bell et al. 2016). Significantly, however, this is happening while parts of the country are experiencing significant growth pressures, which will affect the performance on the current system in an uneven manner. All things being equal, areas that are growing rapidly will need to tackle this issue with more urgency. The political context is also difficult. Existing assets need reinvestment and possible expansion at the same time as the squeeze on local government finances to build new infrastructure to enable growth is becoming ever more apparent.

The changing climate and its impacts

Warming of our climate system is unequivocal (IPCC, 2014) and we are already being affected. With regard to precipitation, it is very likely that there will be an increase in rainfall in the west for winter and spring, while it gets drier in the east and north (Ministry for the Environment, 2016). In summer, it is likely that the east will be wetter, while the west and central North Island is drier. Predicted

increases in rainfall intensity (Pachauri et al., 2014) will also add stress to the system by challenging current design parameters and increase the occurrence of infiltration of wastewater into stormwater.

Droughts are likely to increase in severity and frequency, particularly in already dry areas (MfE, 2016), and wastewater systems will require additional maintenance to protect existing levels of service. Drought will also affect networks, disrupting gravity systems by slowing flow, and may also affect wastewater treatment processes, creating functional and safety concerns.

Sea levels in New Zealand have risen by up to 22cm over the last century, consistent with global trends (MfE, 2017). These are almost certain to rise at a faster rate in future (Royal Society of New Zealand, 2016) and will have a driving effect on what we understand to be a 'normal' climate event. For instance, analysis of four main ports found that the kind of event that is currently expected to have a 1% AEP - a 1-in-100 year event - will occur at least once per year after only a 0.3 to 0.45m sea level rise relative to present-day mean sea level (Stephens, 2015). More broadly, this example brings into question how we communicate risk in a changing climate, in particular regarding the application of historic events when designing for the present and future.

There is also a predicted increase in the severity and frequency of coastal storms. New Zealand has observed a statistically significant increase in waves in the 99 percentile wave height (Young et al., 2011). The most costly areas of our network are often located in low-lying areas or on the coast, which, when combined with storm and tides will increase sewage overflows, erosion, saltwater corrosion, and cause infrastructure failure.

Adaptation and decision-making

The research emphasised how adaptations should be considered as part of an integrated approach and can range from those applied to buildings, or infrastructure assets, through to modification at the scale of a community, or an entire catchment. From a planning perspective, a distinction was also made between differing opportunities and constraints relating to the redevelopment of brownfield sites, new greenfield sites, and retrofitting.

Building scale approaches were seen as appropriate, particularly if assets are of high importance or their failure will result in cascading impacts. Measures include waterproof sealants, raising floor levels, or rainwater harvesting. Integrated approaches adopted across multiple buildings can also manage water on a community level. For example, water can be held back in safe storage areas, slowed to give the receiving infrastructure time to adjust, or retained as a resource to reduce the demands on the system. Upwards in scale, international examples suggest that decentralised approaches can minimise stormwater and wastewater flows at source and reduce demand on existing systems.

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Although, these will have to be linked with parallel public education campaigns to be effective.

Given the uncertainty of climate extremes and the lag in upgrading infrastructure, the research emphasised a change from thinking in terms of "failsafe" to "safe-to-fail". The former focuses on achieving stability, whereas the latter is more appropriate in a system subject to such uncertainty. For example, it considers where excess water can be redirected once design parameters are exceeded. This is essentially moving towards the multi-functional use of space, which moves beyond a development site perspective and is instead a catchment approach to absorbing water.

Internationally, countries are grappling with similar issues. In Europe, for example, the Water Framework Directive and the Flood Directive have served to harmonise water management across the EU and have delivered a real step change in science investment, management between sectors, and the profile of long-term perspectives, such as climate change. This approach links upstream and downstream via a focus on understanding how water flows through an entire catchment from the

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sources through the various pathways to the eventual receptors. This systemic interdisciplinary stance emphasises the need to align clear short-term growth needs with long-term uncertainties, and links more strongly 'structural' aspects, such as infrastructure, with 'non-structural' elements of risk management, such as planning or insurance (White, 2010). The need to engage with new decision support approaches gaining support internationally, such as Dynamic Adaptive Policy Pathways, was also highlighted as a means to enable adaptation over long timeframes.

If we want things to stay the same, things will have to change...

Overall, our systems have been designed to cope with a twentieth century climate that has been assumed relatively stable. The future climate will not only be different, but will see more extremes that will require adapting our buildings, infrastructure, land use, and decision-making.

We identified four integrated areas that need research. The first is to increase our data on the climatic risks to our stormwater and wastewater systems. This will allow us to understand better what is at risk, where, and the consequences of failure, including the cascading indirect effects that we may not yet be aware of. This, in turn, provides a stronger foundation to consider the most appropriate adaptation responses at various scales with regard to both new development and retrofitting.

Buildings, land uses, and assets may have long lifetimes. Once decisions are made, they tend to be 'locked-in' for a generation, which means that it is important to make informed decisions now, even though information is imperfect. Therefore, the final research area involves reconsidering our decision-making frameworks, and the ways that planning, and other areas, can improve their co-ordination and leave a better legacy for future generations. Filling these research gaps will help Aotearoa New Zealand reduce future disruption and cost by adapting our water systems to our changing climate.

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