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INFRASTRUCTURE
COMMISSION
Te Waihanga

The 2023 Auckland Anniversary weekend storm:

An initial assessment and implications for the infrastructure system

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The purpose of this paper is to provide an initial view on:

- the severity of the January 2023 Auckland Anniversary weekend storm resulting in stormwater flooding in Auckland
- the impact of the storm on Auckland's infrastructure
- the issues or weaknesses this event has raised about stormwater management and our infrastructure system.

A version of this paper was commissioned to support a discussion by the Te Waihanga Board in early February 2023 about the impacts and implications of the Auckland Anniversary weekend storm and flooding. Please note that this paper:

- is not intended to provide a full assessment of the impact of the flooding on Auckland, and does not comment on the impact on areas outside of Auckland
- was compiled in the days immediately following the storm, using the limited public information available at the time, meaning that we are necessarily relying on secondary sources of information
- was written before Cyclone Gabrielle reached New Zealand and so refers only to the Auckland Anniversary weekend storm.

Key points

- The January 2023 Auckland Anniversary weekend storm was an extreme rainfall event by any measure.
- Auckland's economic infrastructure appears to have suffered brief and localised loss of service in most cases. Serious and prolonged outages were not widespread and were largely due to landslides rather than flooding.
- Responsibilities for stormwater are fragmented and design standards vary.
- Alignment of stormwater management and land use planning is important, with implications for institutional design.
- Interdependencies between infrastructure networks matter for resilience.
- There is a more fundamental discussion to be had about infrastructure in the face of climate change.

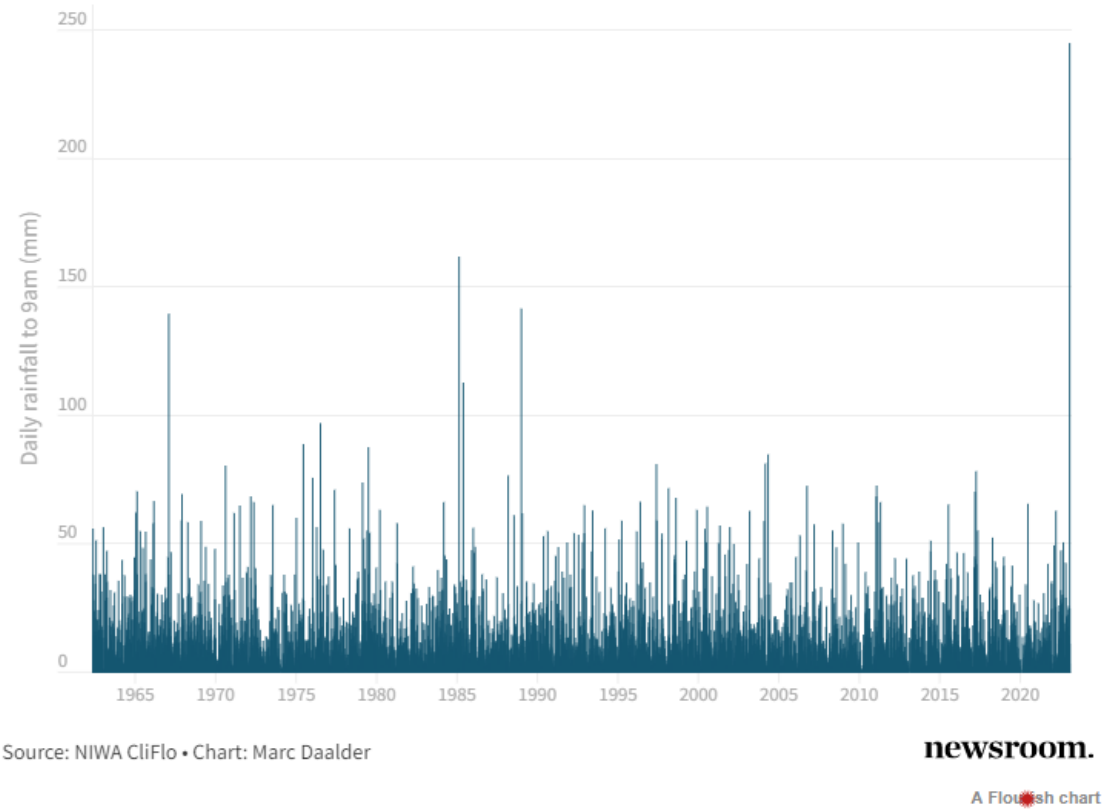
Section 1 – This was an extreme storm by any measure

1. The flooding that occurred as a consequence of the storm that hit Auckland on Anniversary weekend in late January 2023 was unprecedented. It greatly exceeded any previous flooding event in Auckland's history in both intensity and scale.
2. Four people tragically lost their lives[1] and thousands of houses were damaged by flooding and landslides.
3. As of 3 February 2023, Auckland Council had issued:[2]
    a. 209 red placards (entry prohibited, unsafe)
    b. 1085 yellow placards (limited entry)
    c. 1901 white placards (minor damage, safe to enter).

Auckland received 160mm of rain in six hours

4. As per Figure 1, on Friday 27 January 2023, Auckland received approximately 245mm of rainfall in 24 hours,[3] significantly exceeding:
    a. the previous 24-hour rainfall record of 161mm set in 1985[4]
    b. the 198mm of rainfall anticipated in a 24-hour storm once every 250 years[5]
    c. the 242mm of rainfall anticipated over a 72-hour period every 250 years.[6]

Figure 1: Auckland's record-breaking one-day downpour



5. When assessing the significance of a stormwater flooding event, it is important to look at both the quantity and duration of rainfall to determine its intensity. The intensity of rainfall is critical, because the drainage rate provided by stormwater infrastructure is effectively constant and cannot scale up or down. A large volume of rainfall over a four-hour period may exceed drainage systems that the same quantity of rainfall evenly distributed over a 24-hour period might not.
6. 160mm of rain fell on Auckland in just six hours. This exceeds the 134mm of rainfall over six hours that would be associated with a 1-in-250 year storm event in NIWA's worst case climate change forecast.[7]
7. The volume of rainfall was unusual even by international standards (Box 1).

Box 1. The volume of rainfall in Auckland was high even when compared with flooding events in other cities

Year	2008	2013	2017	2021	2021	2021
Location	Dublin floods	Toronto flash floods	Yorkshire floods	Cologne floods	London flash floods	New York City Hurricane Ida
24-hour rainfall depth	**56mm**[8] *(almost city record)*	**138mm**[9] *(city record)*	**82mm**[10]	**154mm**[11]	**42mm**[12]	**181mm**[13] *(city record)*

8. At the time of writing, there is not an authoritative public record of where flooding occurred (the 'inundation area') in Auckland, nor the flood depth by location, or which areas took the longest to drain. Some general observations can be made:
    a. The greatest rainfall was registered in central Auckland and the North Shore,[14] but it is not yet possible to draw inferences about drainage performance.
    b. Much of the inundation damage appears to have occurred in flatter areas where conveyancing capacity is naturally reduced or where there are constrictions to drainage capacity (culverts, narrow channels, etc.).
9. Initial estimates of the economic impact of the floods suggest it will be significant, but well below the costs associated with the Canterbury and Kaikōura earthquakes.

Section 2 – How the storm affected Auckland's infrastructure

10. Auckland's infrastructure appears, in the main, to have been resilient, given the unprecedented intensity of this storm. The table below provides a summary assessment of how various infrastructure services were affected by the floods.

Infrastructure service	Impact and response
Electricity	More than 26,000 properties without power. Over 90% had power restored in less than one day.
Potable Water	More than 3,000 properties without water supply. Water treatment plants unaffected and tap water remained safe to drink. The longest service disruptions were in Titirangi where there were issues due to the Scenic Drive slip.
Wastewater	Significant wastewater overflow into environment. 10 of 800 pumping stations 'severely flooded'. Worst-affected area was the North Shore. 6 of 10 affected pumping stations were operating again by Tuesday.
Telecommunications	Hundreds of properties affected by limited and localised outages, mainly due to power loss.
Waste collection	No notable loss of service. Additional services provided to collect storm debris.
Roads	Impact widespread. More than 39 roads fully closed on Sunday morning. Several bus depots flooded. 80% of scheduled bus services running on Saturday (operating to a Sunday timetable).
Air	Total (but short lived) loss of service. Airport flooded and forced to close. Domestic terminal reopened the next morning with international terminal opening the following morning. Some disruption to both passenger and freight services for several days.
Rail	Major loss of service. Subsidence and landslips damaged tracks on several lines, curtailing some routes, reducing speeds and service frequencies.
Maritime	Ferries suspended during the event and some disruption to port access.
Hospitals	No notable loss of service.
Schools	More than 20 schools with significant damage. Schools reopened several days later.

11. The Auckland Anniversary weekend storm highlighted that the resilience of one infrastructure sector often depends on the resilience of other, enabling, infrastructure services. Failures in one sector can cascade into failures in other sectors.

12. Many of the small-scale telecommunications network outages during the storm occurred not because telecommunications infrastructure was damaged, but because of damage to the electricity infrastructure supplying it. Work to repair the water supply network appears to have taken longer in some areas because of local electrical outages.

Section 3 – This event has highlighted broader issues

Extreme events of this nature are very difficult to manage

13. Stormwater flooding is more difficult to predict than other causes of flooding.[15] Advance warnings of potential flash floods can only be provided a few hours in advance at best, and in many cases only a few minutes before an event.[16]
14. Differing levels of development intensity, and Auckland's varied geology, also increase the challenges involved in managing stormwater across the region. More development typically means more impervious areas, and the prevalence of clay soil means that there is little or no natural storage capacity.

Responsibilities for stormwater are fragmented and design standards vary

15. Much of the drainage infrastructure in Auckland is made up of legacy assets from pre-unification city councils which were developed to different stormwater design standards. Some piped networks were designed for 1-in-2 year events, and some areas have even lower levels of performance.
16. Different standards are applied even within the Auckland Council group. Stormwater infrastructure falls under the remit of both Auckland Council Healthy Waters and Auckland Transport. Design standards are not fully aligned between the two organisations and stormwater service levels are often set on a project-by-project basis. In some instances, it appears that there may be conflicting standards for the same assets.
17. Current design standards provide varying levels of assurance. Piped networks must meet a 1-in-10 year storm threshold. Waka Kotahi specifies 1-in-100 year event standards for bridges, but 1-in-50 year thresholds for low-volume highways. In general, designs rarely consider events larger than a 1-in-100 year intensity.
18. There has been increasing recognition and adoption of low-impact design principles for stormwater management. These principles are only substantially adopted in large developments with master planning, in part because the cost of retrofitting higher stormwater standards to existing developments can be high.
19. Comprehensive plans for managing stormwater flows exist for only localised areas within Auckland.

Alignment of stormwater management and land use planning is important

20. Decisions about how land is used, and how intensively it is used, have impacts on how well severe stormwater events can be managed. In essence, stormwater management presents decision-makers with trade-offs in land use planning. Urbanisation, and the gradual creep of impermeable surfacing, prioritises land use for economic value over the preservation of natural drainage – providing higher benefits on most days, at the expense of sharp costs on storm days.
21. Effective stormwater management aligns decisions about infrastructure investments with those around land use. These investment or land use decisions need not always require the creation of new built infrastructure. For example, councils can channel overflowing stormwaters towards some areas (such as parks) to avoid other areas (such

as housing developments). They can also design roads to convey stormwaters out of communities when drainage systems overflow. This latter option, however, requires careful consideration of whether roads should be protected from flooding in order to keep transport routes open, even if this means that some areas may be more likely to flood as a result.

22. At present, local councils are responsible for both stormwater management and land use management. But, under the Three Waters reform programme, stormwater responsibilities will be transferred from councils to new regional water entities – introducing a new layer of separation between drainage management and urban development. It is not clear how the new water entities will coordinate stormwater management at the regional level with land use planning at the local level.
23. It appears likely that the new water entities will be responsible for the 'grey' infrastructure (such as drains and pipes) but less likely that they will be responsible for the 'green' and other nature-based drainage solutions (such as green roofs, swales and detention basins) that do not fit within the utility model. Those assets more obviously sit in local government alongside land use planning, urban development controls, and parks and outdoor recreation services.
24. This raises questions about how stormwater management will be coordinated across spatial tiers, such as whether flood hazard maps should be produced locally or regionally; whether changes in local drainage will be fed into regional drainage planning; and whether the new water entities will see green infrastructure and nature-based solutions as part of their roles.

Interdependencies matter for resilience

25. Infrastructure operators must ensure that they understand the interdependencies, including how their networks may rely on other, less resilient infrastructure. Resilience planning will depend, in part, on infrastructure operators understanding and planning for cascade failure scenarios.
26. Electricity system failures may result in failures across and within infrastructure sectors in ways that are not immediately apparent. For example, electricity outages can lead to water contamination which can lead to further electricity outages. The pressure inside water pipes protects them against external contamination, even when pipes are damaged. Electricity system outages can cause water pumps to fail, allowing contamination to enter water pipes. Even after the power is restored, residents may be asked to boil water for their safety. That, in turn, can increase the load on an electrical system that may still be under severe strain.

More fundamental discussion is needed about infrastructure in the face of climate change

27. Better information on stormwater and flood risks will be important for planning, and hazard models will need to be updated. Providing better information on flooding risk is highlighted as a priority in the National Adaptation Plan. Actions include, for example, NIWA's five-year project to produce New Zealand's first consistent national flood hazard and risk assessment. This will identify risks and help communities and sectors take early action to reduce costs over time by showing where flooding is likely, and by identifying the vulnerability of communities and assets.

28. However, more fundamental discussion is needed about the level of risk people are willing and able to tolerate, and the costs that should be incurred to manage these. Infrastructure will never be able to eliminate the risk of stormwater flooding.

29. There will always be a difficult trade-off between cost and resilience in infrastructure design. Decision-makers must consider whether to pay a higher price to provide resilience against storm events with longer return periods. This raises difficult questions about who should pay. Stormwater is less obviously conducive to charging than drinking water or wastewater. The most vulnerable communities often cannot afford to invest in their own protection. Because it is not possible to fully protect every community against every rainfall event, prioritisation is required, and trade-offs are inevitable.

30. Private insurance also plays an important part in providing security and resilience, and New Zealand has internationally high levels of cover. However, there is a complex relationship between insurance pricing and infrastructure provision. Insurance premiums are a function of risk, which is (in part) a function of drainage infrastructure.

31. Climate change means more intense and extreme weather events, including heatwaves, droughts and heavy rainfall. This makes insuring infrastructure assets more expensive and more complex. Better information would help asset owners to prioritise their insurance needs. It would also help insurers to set premiums accordingly, providing more accurate pricing signals. More accurate premiums may then, in turn, influence cost-benefit analysis on future infrastructure provision.

Te Waihanga is involved in work to address these issues

32. As part of New Zealand's National Adaptation Plan, Te Waihanga is contributing to the Trifecta Review, which aims to modernise New Zealand's Emergency Management system. Te Waihanga is also involved in the Critical Infrastructure Reform programme, which is considering whether the government's existing regulatory approach to building critical infrastructure resilience is fit-for-purpose. Te Waihanga is developing guidance for assessing risk on physical assets and to the services they provide and is also scoping a resilience standard or code for infrastructure.

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