Written submission on behalf of NIWA

Critical Infrastructure Phase 1 Consultation

Thank you for the opportunity to respond to DPMC consultation on **Strengthening the resilience of Aotearoa New Zealand's critical infrastructure system**.

This submission has been developed from input from several NIWA scientists. As a Crown Research Institute, NIWA's mission is to support the wellbeing of Aotearoa New Zealand's people and businesses through improved management of the environment, sustainable use of natural resources, and effective responses to global change. We deliver on our mission by undertaking world-leading climate, freshwater and marine science, and providing a wide range of services to our stakeholders and clients, which include including government, industry and Māori organisations.

The DPMC discussion document poses specific questions (reproduced in this document using black text), to which we respond below. In addition, we have added a summary at the beginning of our submission and an additional comments section at the end.

Summary of main points

- We support this consultation on New Zealand's critical infrastructure. NIWA has extensive experience in providing science and science services to owners, operators and regulators of critical infrastructure, and we are available to assist DPMC during and after this consultation process.
- We agree that New Zealand's critical infrastructure needs to meet an appropriate level of resilience commensurate with the hazards faced and the direct, indirect and cascading wellbeing impacts that would arise from its failure, taking account of all relevant uncertainties in such an assessment.
- We support the consideration of global megatrends as important context for this consultation. The four megatrends mentioned in the consultation document are correctly identified as threats to critical infrastructure (climate change; a more complex geopolitical and national security environment; economic fragmentation; the advent and rapid uptake of new technologies). In addition, we recommend consideration of additional megatrends such as: changing population demographics; changing social dynamics and polarisation; health crises and pandemics; growing demand and competition for limited resources; and increasing sustainability pressure (e.g., lowering greenhouse gas emissions, responding to the biodiversity crisis).
- We support taking a systems approach to ensure that the resilience of New Zealand's critical infrastructure will be enhanced most effectively and efficiently. There are a variety of organisational arrangements, tools and mechanisms that could enable this, and which will need to be evaluated and rigorously compared in future stages of this consultation. For example, system options may include establishment of a single cross-sectoral infrastructure delivery agency and/or regulator, or alternatively the provision of these functions through separate regional or sectoral agencies.
- Whatever approach is taken for infrastructure system delivery and oversight, several research and data needs must be met (with provision of appropriate resourcing) to enable effective implementation. These include:

    - Development of a shared framework for evaluating hazards and risks across different types of threats and different types of critical infrastructure.
    - Regularly updated risk assessments, including climate change risk assessments, at appropriate spatial and temporal scales.
    - Real-time or near-real-time datasets from e.g., environmental monitoring stations, which provide vital operational intelligence and forecasting for a range of sectors such as agriculture, power and transport.
    - Development of models or modelling approaches to assess the significance of a critical infrastructure asset, e.g., using tools such as dynamic adaptive policy pathways, multi-criteria analysis or similar.
    - Establishment of nationally coordinated, regionally delivered hazard and impact forecasting services, e.g., describing spatial and temporal likelihood of extreme weather events, their effects on river flows (floods) and slope stability (land slips), and the impacts of such effects on critical infrastructure.
- The financial analysis presented in the consultation document is too simplistic. Where costs are given, they are at a high level and do not separate the financial exposure risks associated with specific types of critical infrastructure or compared to other (non-critical) assets. The financial analysis also does not provide much detail on the counter-factual, i.e., the costs associated with not enhancing the resilience of New Zealand's critical infrastructure. Future stages of this consultation will need to be informed by more detailed financial analyses.

Prelude: Objectives for and principles underpinning this work programme

1. Does more need to be done to improve the resilience of New Zealand's critical infrastructure system?

   We agree that the resilience of New Zealand's critical infrastructure systems needs to be enhanced.

   We strongly agree that there are key interdependencies between different types of critical infrastructure, as noted in the box on p.35 of the discussion document. Recognizing that these systems are interconnected is essential, as damage or disruptions in one sector can have cascading effects on others. Proactive and coordinated planning, taking a whole-of-system perspective, is very important.

   We also point out that there are relationships between different types of threats. For example, the impacts of a natural disaster can be exacerbated by climate change. Therefore, in strengthening the resilience of critical infrastructure, it is imperative to incorporate climate change adaptation measures into the planning and design processes. This involves considering future climate projections, implementing robust infrastructure standards, and promoting sustainable practices that mitigate environmental risks.

   We also point out that there are specific concerns relating to lake and river level and flow monitoring, and other concerns, for assessing increasing flood hazards under climate change, for the critical infrastructure above (Hydropower, Renewable Energy Generation, Energy Transmission, Telecommunications, Transport, Stopbanks, New Buildings, etc.). These include:

   - The lack of sufficient observational monitoring, and adequate targeted resourcing to enable this, to critically underpin the assessment of flood hazards under climate change.

- The lack of a federated database for NZ on these critical environmental and infrastructure monitoring parameters is of concern. The efforts to curate a dataset for each national study are repeated every time, wasting resources.
- For Hydropower, the longest and best datasets, although collected by NIWA, are in private ownership (even though some aspects are published intermittently by the Electricity Authority) and can only be used with express permission of the data owners.
- Catchment land-use – Greater consideration required on forestry slash and sediment laden river flood flows in heightening river and floodplain inundation levels.

2. Have you had direct experience of critical infrastructure failures, and if so, how has this affected you?

   NIWA has been heavily involved in provision of science and related services to assist organisations and communities respond to and recover from a range of infrastructure disruptions. This includes NIWA's role in provision of science and related services following the extreme weather events that affected the North Island in January and February of this year, as well as similar events that affected other parts of the country in previous periods.

3. How would you expect a resilient critical infrastructure system to perform during adverse events?

   Firstly, during an adverse event, a resilient critical infrastructure system should withstand disruptions as much as possible. This involves having robust backup systems, redundant infrastructure components, and effective contingency plans in place. Design of these systems needs to be based on the full range of disruptions that might occur, i.e., to ensure that the infrastructure meets relevant design specifications.

   In addition, during an adverse event, a resilient critical infrastructure system needs to have the capability and capacity to quickly assess damage then prioritise and implement responses. This includes the ability to allocate resources (people, funding, etc.) to response activities appropriately and efficiently. As experience from Cyclone Gabrielle shows, it is important for the mechanisms to be used for deployment of resources (e.g., systems for allocation of funding) to be put in place in 'peace time' so that they do not need to be created right within the complex situation of needing to respond to an adverse event. We note that partnerships can be an effective mechanism for enabling immediate response provided these partnerships have been established prior to the adverse event, e.g., that roles and responsibilities of various organisations have been clearly defined.

   As adverse events progress and unfold, a resilient critical infrastructure system needs to adapt and respond to evolving challenges as they arise. Adaptive capacity is key. For example, in the very early stage of an adverse event, recovery of power might be the priority. As the situation unfolds, restoring communication networks may be the next requirement. All the way through such progressing challenges, decision-making about responding to changing risks to life and property are essential. Adaptive capacity is something that needs to be purposefully built before an adverse event occurs, for example through training and exercises involving emergency responders.

   After an adverse event, resilient critical infrastructure systems must be able to incorporate lessons learned into future planning and mitigation strategies. This could include the

consideration of how to incorporate emerging technologies and best practices into standard operations. Effective communication and coordination with stakeholders, including government agencies, private entities, and communities, are also essential.

4. Would you be willing to pay higher prices for a more resilient and reliable critical infrastructure system?

   Infrastructure should be developed and designed according to provide an appropriate level of resilience to the risks it faces and should be priced accordingly.

5. The work programme's objective is to enhance the resilience of New Zealand's critical infrastructure system to all hazards and threats, with the intent of protecting New Zealand's wellbeing, and supporting sustainable and inclusive growth. Do you agree with these objectives? If not, what changes would you propose?

   We agree with these objectives in principle. What's missing is the specificity around the level to which resilience needs to be enhanced. In other words, what is the performance level sought (or conversely, the level of risk that is accepted)? These are decisions that must take account of probability, consequence, cost and residual risk, all within a context of cascading and interacting hazards.

6. Do you agreed with the proposed criteria for assessing reform options? If not, what changes you would propose?

   The proposed criteria are as follows: A) how well does the option enhance infrastructure resilience; B) how does the option change regulatory burden and regulatory certainty across the community; and C) how does the option change the regulatory system's complexity?

   We consider the above-listed criteria to be reasonable, but they are incomplete and insufficiently detailed.

   With regard to completeness, the proposed criteria cover aspects such as relevance and efficiency, but do not cover aspects such as costs, benefits or feasibility of any options considered to improve resilience of critical infrastructure. The consultation document indicates that these are recognised as important criteria but would be brought in at a later stage of consultation. Our view is that these factors should be considered right from the beginning.

   With regard to detail, the consultation document lacks information on the performance levels expected for each criterion. For example, what would differentiate 'very good', 'good', 'adequate' or 'inadequate' levels of changes in the regulatory system's complexity (criterion C)? Fleshing out the descriptions of the various performance levels is necessary so the appropriateness of the criterion can be judged.

Section 1: Background and context

Why a new regulatory approach may be required

7. The paper discussed four mega trends: i) climate change, ii) a more complex geopolitical and national security environment, iii) economic fragmentation, and iv) the advent and rapid uptake of new technologies. Do you think these pose significant threats to infrastructure resilience?

   We applaud the consideration of megatrends in this consultation document. All four of the megatrends that are mentioned in the consultation document are relevant and can create threats to infrastructure resilience.

   As noted in our response to question 1, we also point out that these megatrends are not independent. Rather, there are interrelationships between them that need to be understood and factored into decision-making on enhancing the resilience of New Zealand's critical infrastructure.

8. Are there additional megatrends that are also important that we haven't mentioned? If so, please provide details.

   Changing population demographics also need to be accounted for. This includes urbanisation, aging populations, and immigration, all of which stress existing infrastructure capacities, thereby lessening its resilience to adverse events.

   There is also growing demand and competition for limited resources, such as water, energy, and key minerals and commodities. At the same time, there is increasing pressure to move towards more sustainable practices, such as reducing greenhouse gas emissions and responding to the global biodiversity crisis. This tension between sustainability and limited resource availability is another challenge that needs to be navigated for critical infrastructure systems – many of which rely on these resources, or which may lose social licence to operate if sustainability issues are not effectively considered and addressed.

   Cybersecurity risks are significant and increasing. To some extent, such risks could be considered covered under the umbrella of "new technologies", but the escalating threat cyber-attacks and the increasing dependence on digital systems and interconnected networks should probably be recognised as its own megatrend that can affect critical infrastructure.

   Changing social and political dynamics are also important. This includes things like social inequality, disenfranchisement, polarisation and political unrest. In New Zealand, this megatrend could also include the evolving relationship between Māori and the Crown under Te Tiriti. Addressing these dynamics, and their influence on infrastructure decision-making, requires inclusive processes, effective communication, and equitable distribution of benefits.

   Recent events have demonstrated the vulnerability of critical infrastructure to widespread health crises. Pandemics, infectious diseases, and public health emergencies need to be taken into account in any effort to enhance the resilience of New Zealand's critical infrastructure. This is clearly very applicable to healthcare systems but extends to other types of critical infrastructure

such as transport, communications, computing, etc., which are relevant to rapid response and recovery to health crises.

9. Do you think we have described the financial implications of enhancing resilience accurately? If not, what have we missed?

   The consultation document describes financial implications in general terms. Quantification of costs is largely absent. Where costs are given, they are at a high level and do not separate the financial exposure risks associated with specific types of critical infrastructure or compared to other (non-critical) assets. The financial analysis also does not provide much detail on the counter-factual, i.e., the costs associated with not enhancing the resilience of New Zealand's critical infrastructure. We accept that the consultation is still at an early stage, and so these sorts of more detailed financial analyses may come later.

Section 2: Potential barriers to infrastructure resilience

Building a shared understanding of issues fundamental to system resilience

10. How important do you think it is for the resilience of New Zealand's infrastructure system to have a greater shared understanding of hazards and threats?

    It is important for New Zealand's infrastructure system to develop a shared understanding of hazards, threats and status of resilience. Emphasis is on the word shared, because this implies that there is a common framework used for such assessments. Having a common framework that applies across different types of critical infrastructure will be valuable because it can potentially identify dependencies and feedbacks that, if addressed in a prioritised way, could enhance overall infrastructure resilience most efficiently and effectively.

11. If you are a critical infrastructure owner or operator, what additional information do you think would best support you to improve your resilience?

    For infrastructure owner/operators, the following types of information will be useful for improving resilience:

    - A shared framework for evaluating hazards and risks across different types of threats and different types of critical infrastructure.
    - Regularly updated risk assessments, including climate change risk assessments, at appropriate spatial and temporal scales.
    - Real-time or near-real-time datasets from e.g., environmental monitoring stations, which provide vital operational intelligence and forecasting for a range of sectors such as agriculture, power and transport.
    - Hazard and impact forecasting services, e.g., describing spatial and temporal likelihood of extreme weather events, their effects on river flows (floods) and slope stability (land slips), and the impacts of such effects on critical infrastructure.
    - Decision-making under deep uncertainty tools that have been tailored to identify robust adaptive strategies for infrastructure, ahead of events.

12. What do you think the government should do to enable greater information sharing with, and between, critical infrastructure owners and operators?

    The government should establish and enable provision of the information needs specified in our response to Question 11.

    In addition, given the importance of a wide range of datasets for risk evaluation and forecasting, the government should establish a data system that enables provision and sharing of key datasets while addressing data privacy and security concerns. This is a substantial task but there are building blocks already in place, and there are analogues such as the government databases used to store health and welfare information.

    Once such data infrastructure is established, the government will need to incentivise its use. This could be through training, information campaigns, or other mechanisms such as provision of grants or tax incentives.

    To complement the above, government should lift its R&D expenditure related to risk, hazard and threat assessment. These are complex disciplines which require continual advancement in knowledge, methods and techniques. Such R&D investment would benefit not only our critical infrastructure systems, but also benefit other organisations, communities and sectors of the economy that are exposed to the same sorts of hazards.

Setting proportionate resilience requirements

13. Would you support the government having the ability to set, and enforce, minimum resilience standards across the entire infrastructure system?

    In principle, yes, subject to the details of how it is developed and implemented.

    If so:

    a. what type of standard would you support (eg. requirement to adhere to a specific process or satisfy a set of principles)?

       Firstly, as noted above, we support the development of a National Infrastructure Resilience Framework. Such a framework could specify nationally applicable minimum standards and guidelines for critical infrastructure sectors, noting that these may vary across different sectors (energy, transportation, telecommunications, water supply, healthcare, etc.) based on the impacts forecast to occur in event of their failure.

       We also support the development of national direction and/or regulations that mandate compliance with such a National Infrastructure Resilience Framework. We note however that, like any such national direction, the devil will be in the detail on how it is structured. One example is how any such legislation would (or would not) enable timeframes to be set on a case-by-case basis to allow infrastructure resilience to be built while balancing costs vs. risks.

       We note that there is the option of developing principle-based legislation, e.g., which could specify that critical infrastructure “needs to be resilient” but leaving it to guidance documents to provide the detail on how that would be assessed and enabled. One advantage of leaving the detail in guidance is that it would be more easily updated,

compared to the hurdles involved in updating legislation itself. The disadvantage is that compliance with guidance is typically not enforceable. A middle ground is to establish national standards that sit outside but are referred to specifically in the legislation (e.g., infrastructure "needs to be resilient as specified in current national standards").

With any such national direction, regulation or standard, there would need to be suitably resourced programme for undertaking compliance, monitoring and enforcement (CME). For comparison, New Zealand has recently established the requirement for all farms to develop Freshwater Farm Plans, which means that a whole network of Farm Plan Certifiers and Auditors will need to be established, along with databases to house the associated information, plus new mechanisms that enable regulators to reward compliance and/or fine or otherwise penalise non-compliance.

The same sort of CME and auditing systems will need to be set up to ensure compliance with legislated requirements for maintaining or enhancing the resilience of critical infrastructure, and appropriate training and funding will be required to ensure its successful implementation. An independent oversight body would likely need to be tasked with monitoring and evaluating the resilience of New Zealand's infrastructure system and reporting directly to the government.

b. do you have a view on how potential minimum resilience standards could best complement existing approaches to risk management?

This is a topic that requires further research and evaluation before an informed response can be given.

14. Would you support the government investing in a model to assess the significance of a critical infrastructure asset, and using that as the basis for imposing more stringent resilience requirements?

In principle, yes, subject to the details of how it is developed and implemented.

If so:

a. What options would you like the government to consider for delivering on this objective?

The discussion document lays out a few suitable options on p 35-36, e.g., using simple or more complex (holistic) models to map dependencies and interdependencies with other parts of the infrastructure system, then estimate the full cascading impacts that any disruption to that asset may have, e.g., on people, the economy and the environment.

We support this approach in general and recommend use of holistic rather than simple models where possible. Details on the specific modelling approaches still need to be worked through, which NIWA has expertise to assist with. Modelling options and frameworks that could be employed include dynamic adaptive policy pathways (DAPP), multi-criteria assessment (MCA), robust decision-making (RDM), and machine-learning techniques like reinforcement learning. Expert knowledge also has a role to play and can sit alongside or be directly incorporated into the modelling, depending on the approaches taken.

One important aspect of modelling, not covered in the discussion document, is uncertainty quantification (UQ) and analysis. Essentially, UQ is used to depict the range of plausible outcomes from a range of scenarios run through the model, so that various sources of uncertainty can be evaluated in terms of modelled projections. We recommend that UQ be undertaken according to best-practice methods using suitable techniques, including as applied to the means of communicating the model uncertainties to non-experts. In particular, we note that an understanding of uncertainty is essential to enable application of evaluation Criterion B (p. 9 of discussion document).

b. what criteria would you use to determine a critical infrastructure asset's importance?

One set of criteria should evaluate the wellbeing impacts if the infrastructure asset should fail. Wellbeing can be assessed according to the Living Standards Framework, broadly considering individual and cumulative impacts on social, cultural, economic and environmental dimensions. It is these wellbeing impacts that represent the ultimate end-effects of infrastructure failure.

A second set of criteria should evaluate interdependencies. Apart for the direct wellbeing impacts of infrastructure failure as outlined in the previous paragraph, what indirect impacts to wellbeing could result from failure of other dependent critical infrastructure assets?

There should be a geographic lens taken to both of these sets of criteria. Local impacts are at one end of the spectrum, so need to be assessed in terms of impacts on individuals and communities. The geographic evaluation of impacts should extend all the way to national scale, for example to encompass national security risks arising from infrastructure failure.

In addition to the geographic lens, assessment of the two sets of criteria should also take a temporal perspective. For example, impacts of infrastructure failure may be acute (e.g., as during response to an emergency event) or may accrue over time, as in the case of lessening infrastructure performance (but not complete failure) over a period of years, e.g., due to sea level rise or changing temperatures.

Finally, there is a role for expert judgement and evaluation alongside the assessment of the criteria and spatial/temporal perspectives outlined above.

Managing significant national security risks to the critical infrastructure system

15. Do you think there is a need for the government to have greater powers to provide direction or intervene in the management of significant national security threats against a critical infrastructure?

We agree in principle that appropriate mechanisms need to be in place to enable government to manage risks to critical infrastructure.

If so:

a. what type of powers should the government consider?

The example of the Australian Security of Critical Infrastructure Act 2018 is one model to consider (p. 41). Another model to consider is the establishment of national entities that are mandated to provide and enhance infrastructure services according to legislation and specified standards, and able to generate revenue (e.g., through taxes) to support this, like the Netherlands Rijkswaterstaat.

b. what protections would you like to see around the use of such powers to ensure that they were only used as a last resort, where necessary?

No comment.

Creating clear accountabilities and accountability mechanisms for critical infrastructure resilience

16. Do you think there is a need for a government agency or agencies to have clear responsibility for the resilience of New Zealand's critical infrastructure system?

We agree in principle that clear roles and responsibilities need to be established for all relevant organisations involved in New Zealand's critical infrastructure system – delivery, regulation and oversight.

If so:

a. do you consider that new regulatory functions should be the responsibility of separate agencies, or a single agency?

Both models can work, as shown by the different approaches used in Australia and the Netherlands as just two examples (see our response to Question 15a).

b. do you consider that an existing entity should assume these functions or that they should be vested in a new entity?

Again, both models can work. The key to success lies is in the details, funding, staffing, and any transitional arrangements as the new responsibilities are phased in.

c. how do you see the role of a potential system regulator relative to sectoral regulators?

An overarching system regulator could have the advantage of being able to manage interdependencies and standardise service levels more effectively than a collective of independent sectoral regulators.

17. Do you think there is a need for compliance and enforcement mechanisms (eg. mandatory reporting, penalties, offences) to ensure that critical infrastructure operators are meeting potential minimum standards?

Potentially, yes, as indicated in our response to Question 13a. We note also that a range of incentives can also be used to guide behaviour, instead of or alongside penalties.

If so:

a. do you consider that these should be applied to the entity, to the entity's directors/executive leadership, or a mix of the two, and why?

No comment.

Final comments

18. Please give any other points not already covered above and that you think NIWA should raise in its submission.

We consider that ports should be given greater prominence in the discussion of types of critical infrastructure, given much of New Zealand's imports, exports and national freighting is undertaken by sea. At present ports are only mentioned in a footnote on p. 42 of the discussion document.

We also consider that particular water and storm-related climate change planning and disruptions that need to be given more prominence in the document, across a number of critical infrastructures:

- Hydropower flooding – The risk of extreme flood inundation and damage to the country's hydropower assets (dams and power generating equipment) becomes higher with climate change. Regular revisions are required of design storm rainfall and river flood (and drought) frequencies across NZ as the climate changes. Likewise, consideration of the changing 'probable maximum precipitation' and 'probable maximum flood' is critical for the safety of hydropower dams. These revisions are currently only undertaken when RMA consents need renewing (typically every 35 years). Minimum resilience standards nationwide would seem to be critical for the safety and integrity of NZ's existing and future hydropower generating infrastructure.
- Hydropower droughts – Increasing likelihood of droughts in hydropower catchments impact on supply for increasing electricity demand.
- Renewable Energy Generation – Placement of new renewable energy generation (wind and solar farms) in locations away from or above heights of changing riverine and coastal flood inundation levels, and designed for changing weather extremes (e.g., storm winds for wind farms).
- Telecommunications and Energy Transmission– cell phone towers and energy transmission towers and cables, need to be designed for increasing wind extremes.
- Transport – bridges, roading, airports, rail all need to be designed for increasing inundation hazard levels from rainfall, riverine and coastal flooding sources.
- New cities, buildings, hospitals also all need to be designed for increasing flood inundation hazard levels from riverine and coastal sources.
- Rural and urban infrastructure – protected by stopbanks at appropriate height and risk levels, revised regularly under increasing flood levels and flows.