

Climate Adaptation Options Catalogue

2026 edition

Living library of climate adaptation options for Wellington City.

Absolutely Positively
Wellington City Council
Me Heke Ki Pōneke

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Introduction

The coastal location of Te Whanganui-a-Tara (Wellington, also known as Pōneke), with its steep hills and cliffs, combined with strong winds and rainfall make it very susceptible to natural hazards. Parts of the city are exposed to climate-related hazards, including flooding, coastal inundation and landslides.

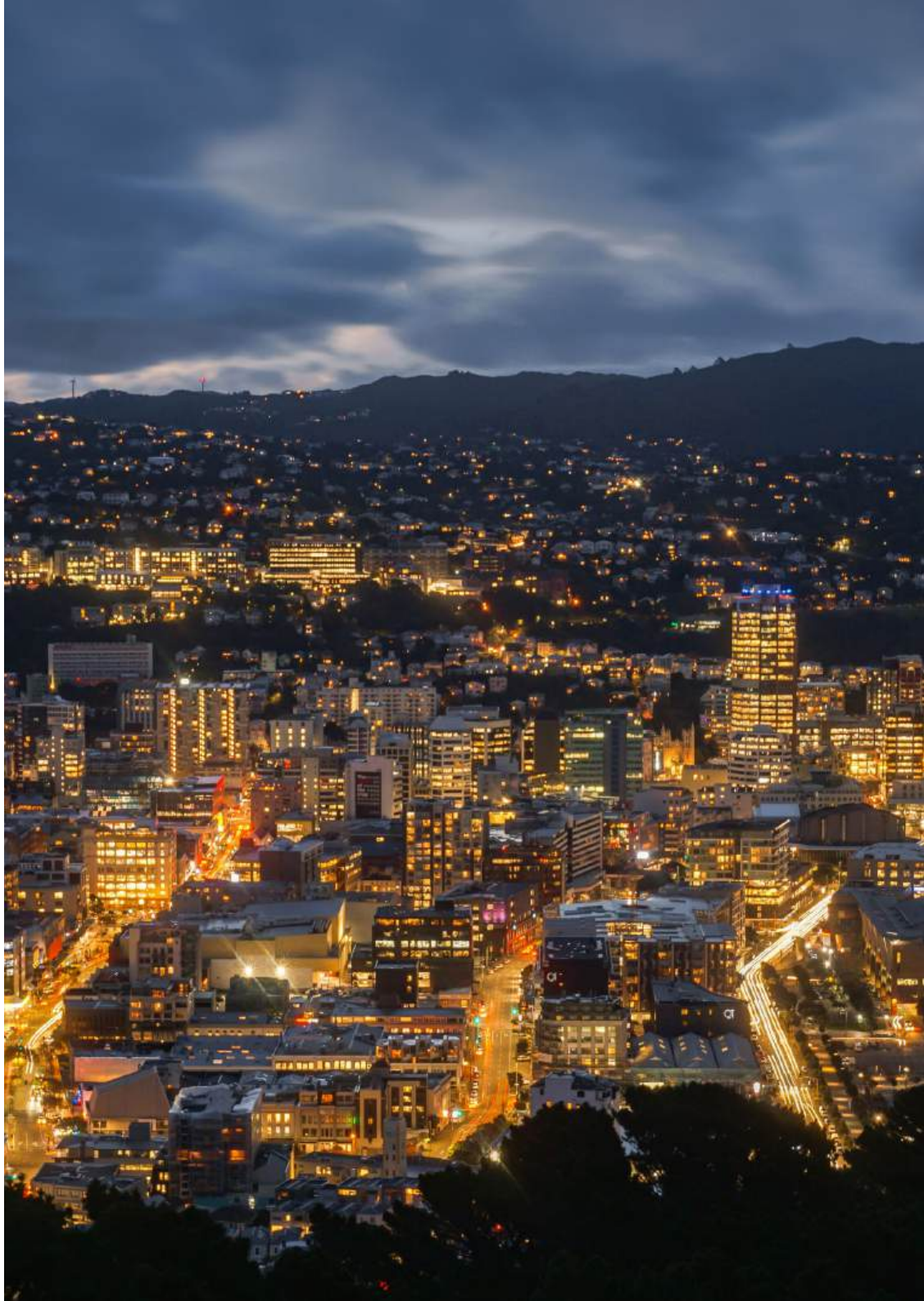
Climate science shows that impacts of climate change are already affecting Wellington, and the projections show impacts will likely worsen over the coming decades and centuries.

Effective adaptation requires flexible long-term planning and implementation of adaptation actions to ensure co-benefits to many sectors and systems.[1] That means in practice, a range of adaptation options are likely to be considered and applied as environmental conditions change that reflect the local circumstances.

This catalogue provides a compendium of adaptation options to support Wellington City Council and its communities to have conversations on climate change and possible adaptation options to address risks arising from flooding, coastal inundation and include extreme wind. There is a wide array of adaptation options and this catalogue is not an exhaustive list. The intent is to provide an introductory guide to a range of adaptation options for the Wellington context.

Other hazards such as earthquakes, tsunamis, liquefaction, wildfire, and drought are not directly included, but interrelationships of options with these hazards are mentioned to ensure a holistic perspective.

1. IPCC AR6 SYR SPM B4



The need for climate adaptation

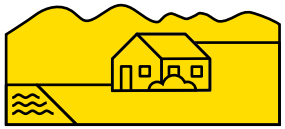
The existence of these climate related natural hazards requires us to take actions to adjust to changing conditions. This need for adaptation has been identified in Wellington's Te Atakura – First to Zero Climate Action Plan. In its Action Area: Adaptation, the plan lays out how we can adapt to climate change, including by coming together as a community to develop adaptation plans.

Adaptation are the actions that help manage, moderate, and cope with the effects of climate change. For example, avoiding building in areas likely to be affected by rising sea levels (Te Atakura First to Zero 2023 Update, p4).

Adaptation options are the array of strategies and measures that are available and appropriate for addressing adaptation (IPCC, p. 2898).

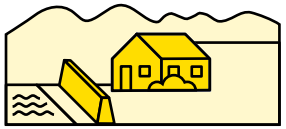
Actions taken to adapt to a climate related hazard can lead to increased risk of adverse climate related outcomes as an unintended consequence, such as increased greenhouse gas emissions or increased or shifted vulnerability to climate change. This is referred to as **maladaptation** (IPCC, p. 2915).

Several types of adaptation options are available for adapting to climate related hazards. Often, they are classified according to whether they protect against, accommodate, retreat from or avoid climate related hazards (called **PARA framework**). Examples for each of these categories are shown opposite.



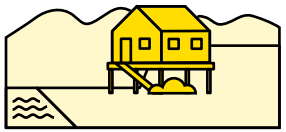
Examples for each of the PARA framework categories

Protect



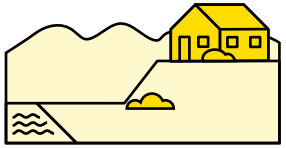
We keep the hazard away.
Protect assets from the hazard through structure (eg stop banks, sea walls) or natural-based (eg restored wetlands).

Accommodate



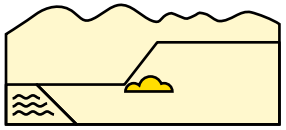
We live with the hazard.
Staying in place by adapting buildings and other structures to make them more resilient to the hazards. Options include things like raising land levels, managing ground and stormwater.

Relocation (also called Retreat)



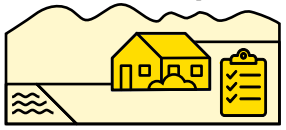
We move away from the hazard.
Moving away from areas where the risk is too high, this can involve proactive relocation or reactive relocation (eg property sales or buyouts).

Avoid



Prevent exposure to the hazard.
Minimise exposure by staying away from areas where the risk is too high. Examples of options include things like land zoning (eg high risk coastal hazard areas).

Maintain status quo



Decision to take no action, but prepare for change.
Level of service may decline over time.

Source: PARA framework, adapted from MfE 'Coastal hazards and climate change guidance' (2024)



Scope of this catalogue

This document outlines adaptation options to address potential risks arising from these four natural hazards that can be exacerbated with climate change.

Flooding both from excess overland water flows as a result of extreme rainfall that overwhelm drainage systems and natural waterways (pluvial flooding) and from overtopping/flooding of awa (rivers and streams, also known as fluvial flooding);

Coastal inundation (including from sea level rise, combined with storm surges and wave action); and

Landslides can occur on natural steep slopes or modified cut/fill slopes and be triggered by a combination of rainfall, treefall, water leaks, poor earthworks or seismic events.

Exteme wind on exposed hillsides and ridgelines.

These have been identified as the key climate related natural hazards for Wellington based on the best available data. Other hazards such as earthquakes, tsunamis, liquefaction, wildfire and drought are not directly included, but interrelationships of options with these hazards are mentioned to ensure a holistic perspective.

Flexible approach to climate adaptation

The Ministry for the Environment in its 'Coastal hazards and climate change guidance' (2024) recommends using a **10-step decision cycle for adaptation** to coastal and other climate-related hazards (see figure opposite). This includes the identification and evaluation of adaptation options (steps 5 and 6) and the use of the dynamic adaptation pathways planning (DAPP) approach.

In practice, a suite of options should be considered that reflect the local circumstances. The recommended dynamic adaptation pathways planning (DAPP) approach does not prescribe one single solution, but leaves future solutions for future decisions. It does so by identifying adaptation pathways made up from different options that might be suitable to adopt in the future once conditions change.

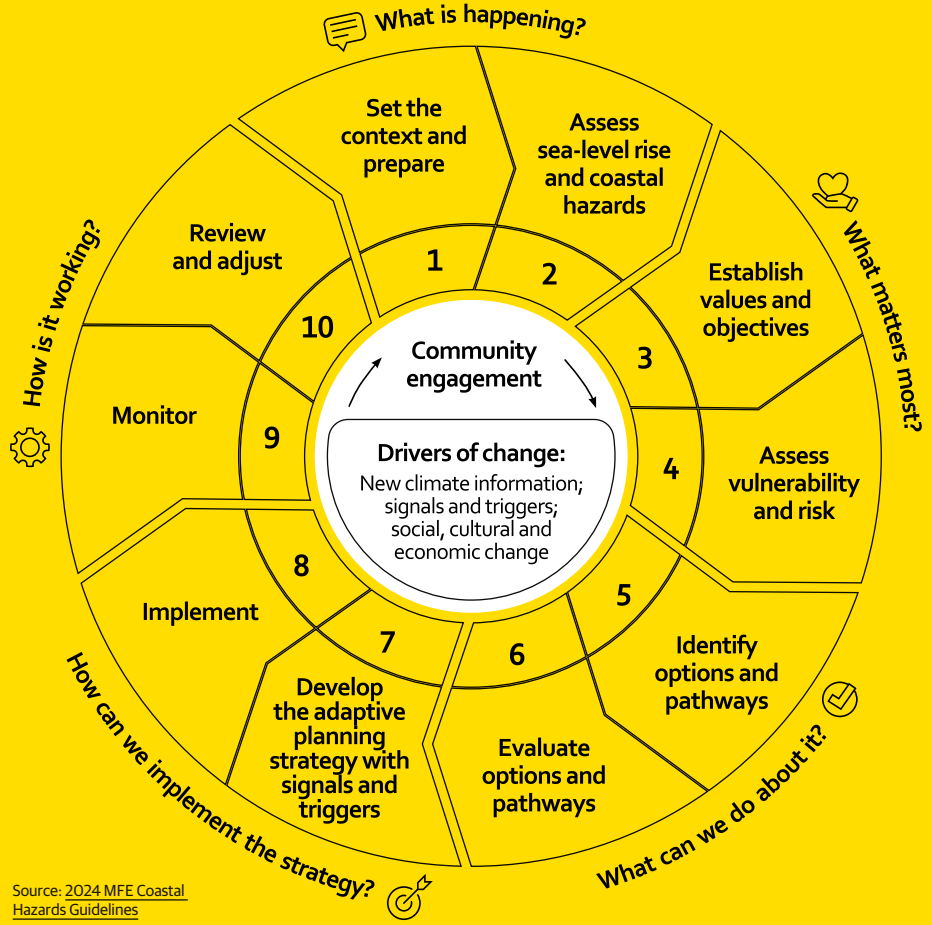
Once options and pathways have been identified, it is important to evaluate what is a good adaptation option or pathway. Evaluation criteria might include ability to meet objectives, flexibility to change in the future and avoid maladaptation, feasibility of implementation, costs, ability to meet community values and provide further co-benefits and adverse effects among others.

Partnership with mana whenua and involvement of the local community is integral to the identification and assessment of options.

More information on DAPP as well as evaluation techniques for adaptation options are provided in the Ministry for the Environment's Coastal Hazard and Climate Change Guidance.

Identification and assessment of options are integral to adaptation planning.

Effective adaptation requires holistic and flexible long-term planning together with mana whenua and local communities, the integration of western theory as well as mātauranga Māori and implementation of adaptation actions to ensure co-benefits to many sectors and systems.



Source: 2024 MFE Coastal Hazards Guidelines

Mātauranga Māori

All options have the potential to be informed by mātauranga Māori (eg in relation to design, suitability, location and/or operation). A detailed assessment of specific options that includes mana i te whenua values and mātauranga is contextual, place-based, and highly variable, and at the discretion of mana i te whenua.

Early and meaningful involvement of mana i te whenua in the identification, assessment and selection of adaptation options is essential.

This document includes only high-level potential advantages and disadvantages of options from a te ao Māori perspective. For example regarding the potential for impacts on taonga species and wāhi tapu, water flows/mauri enhancement, or the ability of Māori to stay in their kāinga/ancestral lands.

The document mentions examples led and/or informed by mātauranga-a-whānau/hapū/iwi (ie Māori knowledge) which have also been sourced from iwi and hapū beyond Wellington City Council.
In practice, mana whenua would be called upon to inform mātauranga-led options for the Wellington region, which may not yet be listed in this guide. The range of options is expected to expand over time.

Mana whenua would be called upon to inform mātauranga-led options for the Wellington region...



Description of adaptation options

Summary information is given for each adaptation option. This includes both identification of key characteristics in form of icons as well as high level descriptions.

Key characteristics displayed as symbols include:

- **PARA classification**: **Protect, Accommodate, Relocate/Retreat, Avoid**
- **Hazard/s addressed**: flooding, coastal inundation and/or landslides and wind

Hazards addressed:



- **Cost range** (over the anticipated design life of the option): $,$$,$$$;

Cost:



- **Timeframe (likely)** (ie the anticipated design life of the option): short (0–20 years), medium (20–50 years), or long term (50–100 years);

Timeframe:

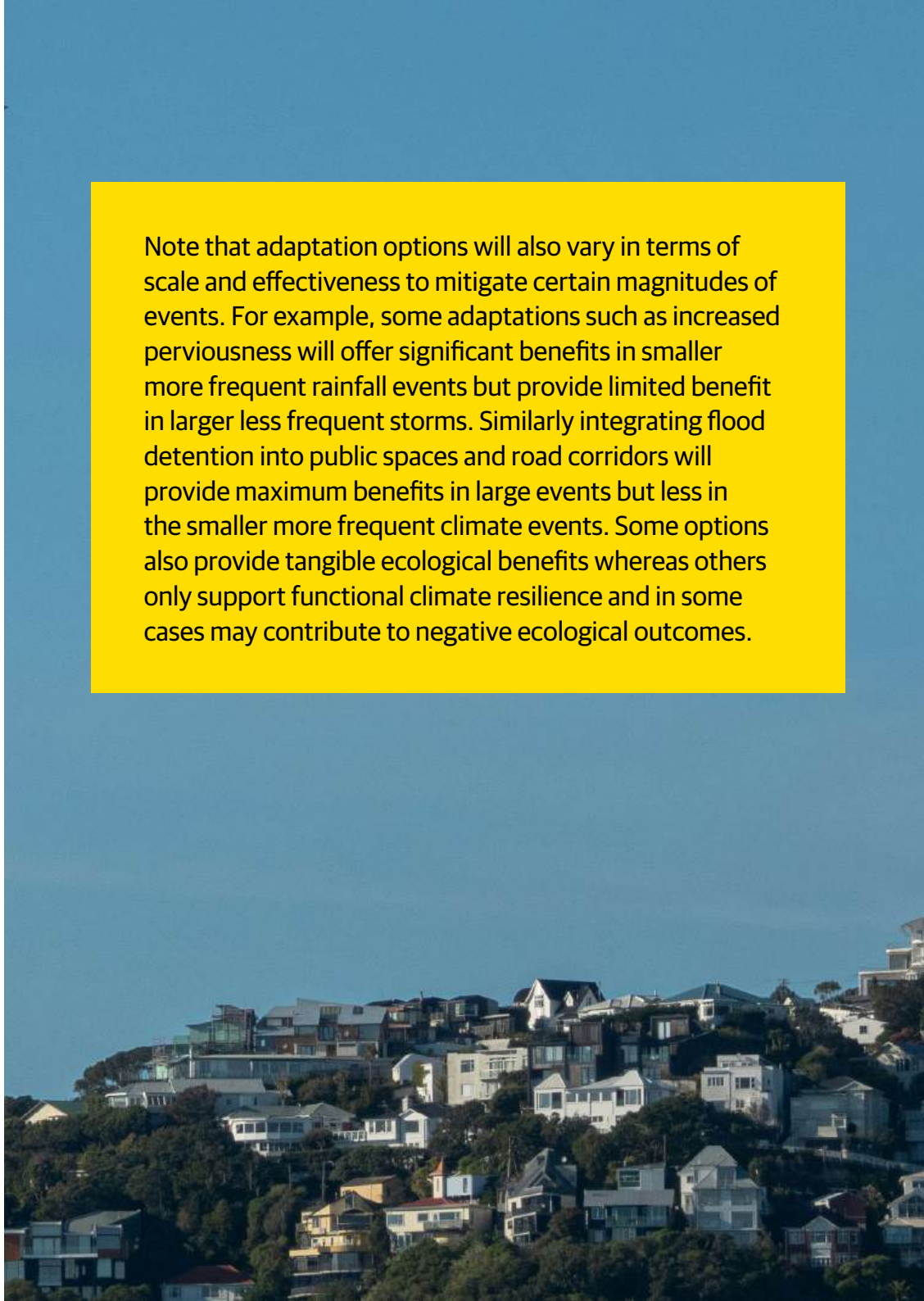


- **Consenting requirements** (whether the option is likely to be subject to resource and/or building consent): unlikely, possible, likely, n/a.

Building and/or resource consent:



Note that adaptation options will also vary in terms of scale and effectiveness to mitigate certain magnitudes of events. For example, some adaptations such as increased perviousness will offer significant benefits in smaller more frequent rainfall events but provide limited benefit in larger less frequent storms. Similarly integrating flood detention into public spaces and road corridors will provide maximum benefits in large events but less in the smaller more frequent climate events. Some options also provide tangible ecological benefits whereas others only support functional climate resilience and in some cases may contribute to negative ecological outcomes.



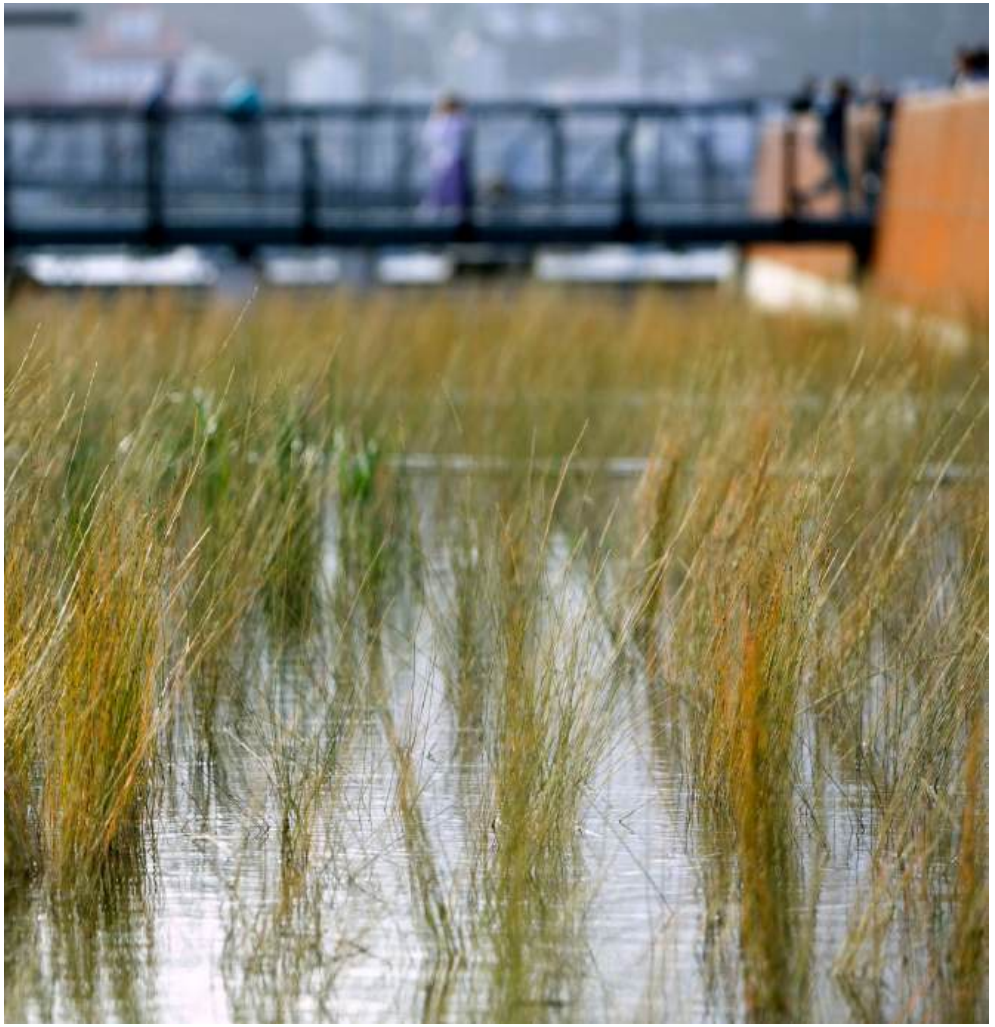
Water catchment approach to climate adaptation

Wellington City Council is preparing for climate change by planning at the scale of each water catchment – from the hilltops to the coast. A catchment is simply the area where rain naturally flows into streams, stormwater systems, and eventually the sea. Even as Wellington has grown and streams have been piped or altered, the pathways water follows remain the same.

Climate change is increasing the pressure on these systems. Heavier rainfall, rising sea levels, higher tides, and coastal storm surges can now combine to increase flooding and put stress on homes, roads, and essential infrastructure.By assessing risks catchment by catchment, the Council can better understand how inland flooding and coastal hazards connect and what this means for local communities. This helps ensure that climate adaptation actions are targeted, effective, and based on how water actually moves through the landscape.

Mātauranga Māori (Māori knowledge) also supports this approach. It recognises the deep connections between land, water, people, and ecosystems, and emphasises the importance of ki uta ki tai – from the mountains to the sea. This aligns closely with catchment based planning, which looks at the whole system rather than individual parts. Working with mana whenua helps ensure adaptation planning respects cultural values, supports the health of waterways, and strengthens long term resilience or both people and the environment.

This approach reflects modern, water sensitive urban planning that aims to build resilience, protect the environment, and manage stormwater more sustainably. The Council is also developing new tools and modelling methods to assess stormwater options at the catchment scale, which will help guide future planning and will be made publicly available.





Key considerations for building climate resilience

Most of the potential adaptation options described in this document share some common characteristics for climate adaptation planning, including:

- **Systems approach:** options are likely to be designed as part of a system of other options, either directly in the location (eg pumps in floodable basements) or over time (eg dune restoration as a measure to buy time before retreating).
- **Reduction in loss and damages**: options aim to reduce risk to life and/or damage from the hazard to buildings, infrastructure and wāhi tapu, and hence reduce future repair costs.
- **Changes over time have thresholds and triggers:** options are generally designed to withstand a hazard of a certain size (eg 1 in a 100-year flood, sea level rise up to a certain level) and are prone to failure if this design capacity is exceeded or they are not appropriately maintained.
- **Multi-hazard management:** option design should consider a range of known hazards (eg earthquakes, liquefaction).
- **Transformational adaptation:** goes beyond incremental changes, seeking to fundamentally address root causes of climate change vulnerabilities using a wholistic systems approach.

Each option is then described and images and examples (local where possible) are provided. Benefits and Limitations include environmental, economic, technical, socio-cultural, carbon and implementation aspects. The flexibility to respond to future uncertainties and interdependencies with other hazards such as erosion, earthquakes, liquefaction, tsunami, wildfire, and drought is also indicated. In order to avoid maladaptation, this report highlights any potential unintended consequences of an option on other hazards as well as the option's impact on greenhouse gas emissions.

Categories of adaptation options

Adaptation options have been categorised into the following categories:

- **Buildings** includes actions that can be taken at individual property level to adapt to climate related hazards.
- **Infrastructure general** includes actions to increase the resilience of infrastructure (eg energy, telecommunications, transport, waste, social).
- **Stormwater infrastructure** refers to formal engineered infrastructure for surface water management, such as stormwater pipes, central pump stations and detention basins.
- **Nature-based solutions** include the use and management of natural ecosystems and processes, or engineered systems that mimic natural processes, to reduce greenhouse gas emissions, support climate change adaptation and/or strengthen the resilience and wellbeing of people, indigenous biodiversity, and natural and physical resources to the effects of climate change.
- **Structural or hard protection** approaches aim to stabilise shorelines, riverbanks or unstable slopes by constructing seawalls, dykes or retaining walls.
- **Strategic and land use planning** policies that aim at avoiding or minimising risk through long term, including retreat, through land use and spatial plans; and
- **Community resilience initiatives** that build community capacities to reduce risks, prepare and respond to natural hazard events and wider changes, and recover well.



Climate Adaptation Options Summary Table

Category	Option	PARA category	Hazard(s) addressed	Cost range	Timeframe (Likely)	Consent requirement
Buildings	Retrofit rainwater detention tanks	Accommodate	Flooding	$	Medium term	Possible
Buildings	Retrofit rainwater retention tanks	Accommodate	Flooding	$-$$	Medium term	Likely
Buildings	Building scale flood pumps	Accommodate	Flooding, Coastal inundation, Storm surge	$-$	Short term	Possible
Buildings	Elevated buildings	Accommodate	Flooding, Coastal Inundation	$	Short-Medium term	Likely
Buildings	Flood protected buildings	Protect	Flooding, Coastal inundation, Storm surge	$-$$	Short term	Possible
Buildings	Adaptable buildings	Accommodate	Flooding, Coastal inundation	$	Medium term	Likely
Buildings	Wind resilient buildings	Accommodate	Wind	$	Short-Medium term	Likely
Buildings	Raised building platforms or land	Accommodate	Flooding, Coastal inundation	$-$	Medium term	Likely
Buildings	Living / green roofs and walls	Accommodate	Flooding	$	Short-Medium term	Likely
Buildings	Garden improvements / landscaping (incl. permeable fencing)	Accommodate	Flooding, Landslides	$	Short-Medium term	Not likely
Infrastructure - General	Increase capacity and durability of existing infrastructure	Accommodate	Flooding, Coastal inundation, Wind	$	Medium-Long term	Likely
Infrastructure - General	Regrading of road cross sections	Accommodate	Flooding	$-$$	Short term	Unlikely
Infrastructure - General	Optimised infrastructure operation and management	Accommodate	Flooding	$	Short term	Unlikely
Stormwater Infrastructure	Water sensitive urban design (WSUD) in redevelopment	Accommodate	Flooding, Coastal inundation	$-$$	Long term	Likely
Stormwater infrastructure	Overland flow-path management	Accommodate	Flooding	$	Medium term	Possible
Stormwater infrastructure	Public flood detention infrastructure	Accommodate	Flooding	$	Medium term	Likely
Stormwater infrastructure	Wastewater inflow mitigation	Protect	Flooding, Coastal inundation	$-$	Medium term	Likely
Stormwater infrastructure	Centralised pump stations	Accommodate	Flooding	$	Medium term	Possible
Stormwater infrastructure	Existing stormwater infrastructure management and upgrade	Accommodate	Flooding	$$$	Medium-Long term	Likely
Nature-based Solutions	Increased pervious surfaces	Accommodate	Flooding	$	Medium term	Possible
Nature-based solutions	Dune restoration	Protect	Coastal inundation, Erosion	$	Short-Medium term	Likely
Nature-based solutions	Rain gardens / bioretention	Protect	Flooding	$	Short term	Likely

Climate Adaptation Options Summary Table

Category	Option	PARA category	Hazard(s) addressed	Cost range	Timeframe (Likely)	Consent requirement
Nature-based solutions	Constructed wetlands	Accommodate	Flooding	$	Medium term	Likely
Nature-based solutions	Vegetated swales	Accommodate	Flooding	$-$	Medium-Long term	Likely
Nature-based solutions	Stream daylighting	Accommodate	Flooding	$$	Medium-Long term	Likely
Nature-based solutions	Stream restoration	Accommodate	Flooding	$	Medium-Long term	Likely
Nature-based solutions	Natural wetlands (restored or preserved)	Accommodate	Flooding, Coastal inundation	$	Short term	Possible
Nature-based solutions	Riparian planting	Accommodate	Flooding, Landslides	$-$	Medium term	Unlikely
Nature-based solutions	Living shorelines	Protect	Coastal inundation	$	Medium term	Likely
Nature-based solutions	Seaweed restoration	Protect	Coastal inundation	$	Medium term	Possible
Nature-based solutions	Wind breaks and planting barriers	Accommodate	Wind	$-$	Short term	Likely
Nature-based solutions	Vegetating hills and slopes	Accommodate	Flooding, Landslides, Wind	$-$	Short term	Unlikely
Hard protection / Structural	Slope stabilisation / retaining walls	Protect	Landslides	$-$$	Medium term	Likely
Hard protection / structural	Seawalls	Protect	Coastal inundation	$-$$	Short-Medium term	Likely
Hard protection / structural	Breakwaters and artificial reefs	Protect	Coastal inundation	$-$$	Short-Medium term	Likely
Strategic and Land-Use Planning	Building and development standards	Accommodate	All hazards	$-$	Short-Medium term	N/A
Strategic and land-use planning	Resilient service routes	Accommodate	Flooding, Coastal inundation, Landslides	$-$$	Medium-Long term	Possible
Strategic and land-use planning	Pro-active strategic relocation	Relocate / Retreat	Flooding, Coastal inundation, Landslides	$$	Medium-Long term	N/A
Strategic and land-use planning	Re-active relocation	Relocate / Retreat	Flooding, Coastal inundation, Landslides	$$	Short-Medium term	N/A
Strategic and land-use planning	Restricting development in high-risk areas	Avoid	Flooding, Coastal inundation, Landslides, Wind	$	Medium-Long term	N/A
Strategic and land-use planning	Spatial, growth and infrastructure planning	Avoid	Flooding, Coastal inundation, Landslides, Wind	$	Medium-Long term	N/A

Climate Adaptation Options Summary Table

Category	Option	PARA category	Hazard(s) addressed	Cost range	Timeframe (Likely)	Consent requirement
Community Resilience Initiatives	Community emergency preparedness and response	Accommodate	Flooding, Coastal inundation, Landslides, Wind	$	Short-Medium term	Not likely
Community resilience initiatives	Community public education	Accommodate	Flooding, Coastal inundation, Landslides, Wind	$	Short-Medium term	Unlikely
Community resilience initiatives	Educational signage	Accommodate	Flooding, Coastal inundation, Landslides, Wind	$	Short-Medium term	Unlikely
Community resilience initiatives	Monitoring hazards and effectiveness	Accommodate	Flooding, Coastal inundation, Landslides, Wind	$	Short-Medium term	Not likely



Adaptation Options

Buildings

Adaptable buildings

PARA category:

Accommodate

Hazards addressed:



Cost:

$ | **$$** | $$$

Timeframe:

S | **M** | L

0 20 50 100

Building and/or resource consent:



Adaptable buildings are built and used in ways that accommodate future changes in environmental conditions.

This includes relocatable houses that can be moved elsewhere when conditions change or design that enables future raising of floor levels.

Benefits:

- Can increase design life, value, saleability and insurability of the building.
- Potential for increased amenity (eg living right by the water), and recreational opportunities (eg boat access).
- Provides flexibility to adapt to future changes.
- Potential for low embodied and/or operational carbon emissions (eg through reuse/ recycling of materials), or longer lifespan.

Limitations:

- Potentially increased building costs, depending on design, borne by owner, which might increase inequalities.
- Likely to require resource and/ or building consent.
- Potentially reduced access to building during flood (assuming road is not raised).
- Might require further incentives (eg rates rebates) or regulations (eg district plan rules) for widespread uptake.
- Takes time for the housing stock to be renewed.
- Can incentivise further development in exposed areas and hence increase future vulnerability.

Examples:

- Relocatable homes – designed and built with ability to move in future in response to rising sea levels.



A modern floating house

Retrofit rainwater detention tanks

PARA category:

Accommodate

Hazards addressed:



Cost:

$	**$$**	$$$

Timeframe:

S	**M**	L

0 20 50 100

Building and/or resource consent:



Detention is where stormwater is captured in a tank and slowly released at a controlled rate (detained) during large storm events to reduce the risk of downstream flooding. A detention tank is therefore a sealed tank serving an individual property designed to collect peak rainwater runoff from roofs. carparks and other impermeable surfaces and slowly release captured water over an extended timeframe. Can be above or below ground but must be able to drain without the use of pumps. Tanks throttle outflow during rainfall to control stormwater runoff and reduce peak flows to reduce flooding and pressure on downstream stormwater systems.

This approach aligns with the Wellington District plan objectives of achieving hydraulic neutrality in Wellington by maintaining offsite stormwater peak flows to match the predeveloped conditions. Targeted installation of detention tanks in existing developed area can provide effective flood mitigation where other options (such as large-scale detention storage) are not viable. This can be combined with rainwater retention capacity for additional environmental benefits (see Rainwater retention tanks).



Rainwater detention tank on residential dwelling (Watersmart)

Benefits:

- Able to be delivered through targeted retrofit programme.
- Low tech solution requires only basic maintenance.
- Aligns with hydraulic neutrality requirements.
- Can design tank to include a separate proportion of retention storage for hydrological controls or emergency supply.
- Can design to minimise visual intrusion (eg tank colours/ buried in ground).
- Provides flexibility to adapt to future changes.

Limitations:

- Costs for installation borne by owner, which might increase inequalities.
- The layout and existing drainage of many properties make them unsuitable for retrofitted tanks.
- Potentially high embodied carbon emissions depending on tank materials.
- Requires ongoing maintenance (albeit limited) to ensure sustained protection.
- Requires land space with limited use (only during peak events).
- Might require further incentives (eg rates rebates) or regulations (eg district plan rules) for widespread uptake.

Examples:

- Detention tanks for hydraulic neutrality.

Retrofit rainwater retention tanks

PARA category:

Accommodate

Hazards addressed:



Cost:

$ **$$** **$$$**

Timeframe:

S **M** L

0 20 50 100

Building and/or resource consent:



Retention is where stormwater is captured in a tank and used (retained) within the property to reduce the volume of water that is discharged in small rainfall events which ordinarily would not generate stormwater runoff in an undeveloped condition.

Uncontrolled runoff from building roofs changes flowrates and volumes in smaller frequent events which can cause erosion and water quality impacts on downstream waterways. Retention tanks collect stormwater from impervious surfaces during moderate/heavy rainfall events and prevent it leaving properties either through reuse of harvested water or infiltration to ground (or a combination). Tanks can be above or below ground and are usually made of plastic or concrete. Captured water is used (or soaked to ground) to mimic the natural interception, evapotranspiration and infiltration of rainfall in an undeveloped catchment to protect downstream waterways. Water is suitable for non-potable uses (toilet flushing, laundry or irrigation) unless treated for drinkability. Rainwater retention tanks support requirements for hydrological controls and can also provide flood mitigation when rainfall coincides with tanks being empty or close to it. Retention tanks are also well suited to be coupled with technology innovations such as 'smart' tanks which can automatically drain tanks when heavy rainfall is forecast to provide flood storage volume or used to increase natural baseflows in waterways in times of drought.



Benefits:

- Able to be delivered through targeted retrofit program.
- Easy to retrofit to many buildings where roof downpipes drain to suitable location.
- Low tech solution with limited moving parts and basic maintenance.
- Aligns with hydrological control requirements.
- Protects sensitive freshwater biodiversity in downstream waterways.
- Can reduce demands on mains water and reduce water usage rates. Can function as alternative water source in case of emergencies (eg water network outage, earthquakes).
- Can design tank to include a separate proportion of detention storage above retention for hydraulic neutrality.
- Can design to minimise visual intrusion eg tank colours/ buried in ground.

Limitations:

- Costs for installation borne by owner, which might increase inequalities.
- Many properties unsuited to retrofit tanks due to building typologies and existing drainage positions.
- Limited benefit in large flood events unless tank empty or detention storage integrated above retention volume.
- Requires ongoing maintenance by building owners (albeit limited) to ensure sustained function.
- Might require further incentives (eg rates rebates) or regulations (eg district plan rules) for widespread uptake.
- Potentially high embodied carbon emissions depending on tank materials and pumping.
- Likely to require resource and/or building consent.

Examples:

- Aquarevo – residential development in Melbourne with full rainwater collection and reuse for retention.
- Tanks for Platypus Yarra Ranges Council – residential reuse tanks to support ecological outcomes.
- Slimline rainwater retention tank on residential dwelling (Watersmart).

Flood Protected buildings

PARA category:

Protect

Hazards addressed:



Cost:

$** **$$** **$$$

Timeframe:

S M L

0 20 50 100

Building and/or resource consent:



A building is protected through physical structures sealed to prevent floodwaters from entering. This can be done through the installation of temporary or permanent devices such as door barriers, deflection walls, watertight window shields, flood gates, as well as the use of sealants and membranes to reduce seepage of floodwaters through walls. Might need to be paired with other options, eg pumps to prevent ponding from rainwater or rising groundwater within line of protection.



Removable flood barrier for door. Image courtesy of Lakeside Flood Solutions

Benefits:

- Relatively easy to install and maintain.
- Can increase design life, value, saleability and insurability of the building.
- Potentially low embodied carbon emissions (depending on materials used).

Limitations:

- Costs borne by owner, which might increase inequality.
- Requires early warning systems and awareness and appropriate and timely actions by owner.
- Might temporarily impede access to building during flood.
- Potential to increase flood risk to neighbouring properties (eg from flood water being diverted onto their land).
- Flood shields and sealants may not be aesthetically pleasing.
- Might require further incentives (eg rates rebates) or regulations (eg building standards update) for widespread uptake.

Examples:

- Built in flood barriers to be activated during events and temporary flood barriers erected during flood events (Watersmart)

Building scale flood pumps

PARA category:

Accommodate

Hazards addressed:



Cost:

$** **$$ $$$

Timeframe:

S M L

0 20 50 100

Building and/or resource consent:



Pumps that remove flood waters out from individual properties or neighbourhood areas, with water pumped to designated pits, stormwater drains, streams, high capacity drains with other options (eg wetproofing of buildings or flood gates). Some communities could own mobile pumps that can be transported to flooded areas to help mitigate impacts during and immediately after flood events.

Benefits:

- Relatively easy to implement and operate, with increasing options for automation (eg pump turns itself on if certain water levels are detected).
- Provides flexibility to adapt to future changes.

Limitations:

- Requires pipe system and land for installation of detention pit or tank where water can be pumped to.
- Costs for installation borne by owner, which might increase inequalities.
- Requires ongoing maintenance and/or upgrades.
- Potential negative impacts on neighbouring properties (eg from flood water being diverted onto their land).
- Potential operational carbon emissions (eg depending on how electricity required for pump operation is generated).

Examples:

- Use of flood pumps during Auckland Anniversary weekend flooding.
- Building scale flood pump – see photo.



Flood pump after flooding

Wind resilient buildings

PARA category:

Accommodate

Hazards addressed:



Cost:

$	$$	$$$

Timeframe:

S	M	L

0 20 50 100

Building and/or resource consent:



More frequent high winds are putting added pressure on exposed homes, especially in identified high wind zones. New builds and renovations in these zones must be designed to be more resilient, for example by strengthening wall bracing and roof fixings. securing subfloors, anchoring items like solar panels and chimneys. and using tougher. impact resistant glass. Outdoor items and large doors (such as garage doors) should also be secured during severe weather, and trees that could fall on homes need regular assessment. For properties in flood prone or coastal inundation areas, appliances and electrical equipment should be kept above expected flood levels, and materials such as flooring and wall linings should be chosen for their ability to withstand occasional flooding.

Benefits:

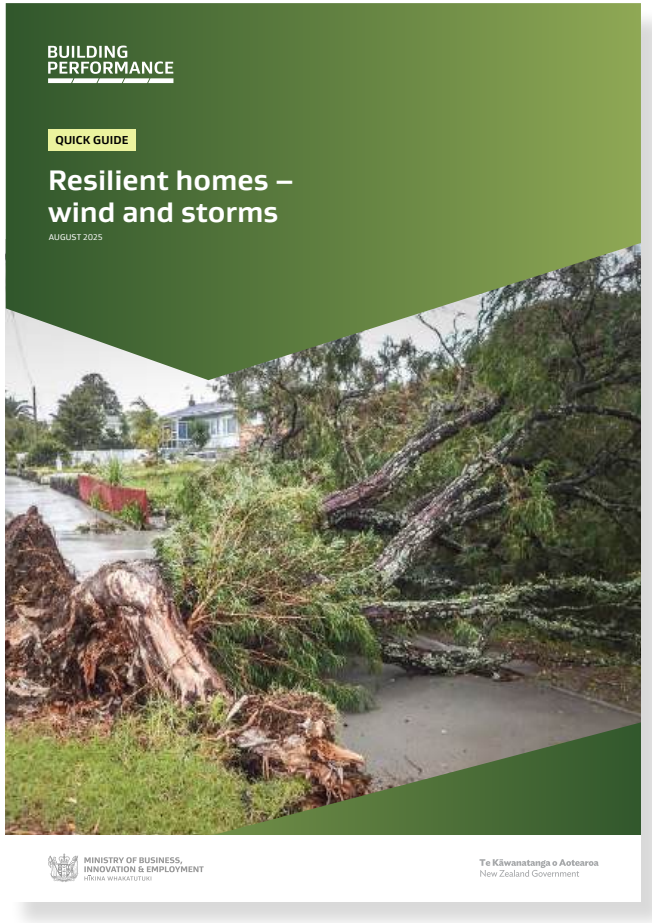
- Can increase design life, value and saleability of property.
- Increased noise damping inside houses.
- Improves buildings above building standard minimums.

Limitations:

- Costs for installation are borne by owner, which might increase inequalities.
- Can be hard to retrofit without significant works.
- Less effective for more complex house or roof designs which can be necessary for complex site topographies.
- Might require further incentives (eg rates rebates) or regulations (eg district plan rules) for widespread uptake by private entities.
- Unable to mitigate all weather events in high wind zones.

Examples:

- BRANZ guidelines.
- Flood: Repairable House practitioner's handbook.



Living/green roofs and walls

PARA category:

Accommodate

Hazards addressed:



Cost:

$	$$	$$$

Timeframe:

S	M	L

0 20 50 100

Building and/or resource consent:



Planting of vegetation or garden beds on the roofs or along the walls of private, commercial or industrial buildings of any size to prevent runoff generation from an otherwise impervious area at source and temporarily store and slow down water flows. Bigger living roofs and living walls are usually connected to the stormwater systems, so water release into the stormwater system after heavy rainfall can be controlled. These can be installed on new buildings or retrospectively fitted if structural design allows.

Benefits:

- Can increase design life, value and saleability of property.
- Creation of habitats for flora and fauna, in otherwise unused urban spaces.
- Opportunity to include mātauranga and Māori values for design and plant selection.
- Provides wider ecosystem services (eg water filtering, water storage, nutrient accumulation, decrease of surface temperatures, building insulation, improved air quality).
- Increased amenity (including noise reduction), recreational opportunities, and opportunity for cultivation of māra kai/ mahinga kai.
- Can act as carbon sink (eg if recycled plastics or zero-plastic aggregates used).

Limitations:

- Costs for installation and maintenance are higher than for a normal roof and borne by owner, which might increase inequalities.
- Careful structural loading and waterproofing is needed to avoid leakage into building.
- Might require further incentives (eg rates rebates) or regulations (eg district plan rules) for widespread uptake by private entities.
- Requires ongoing maintenance and pest management.
- Limited benefits for larger magnitude events due to limited capacity.

Examples:

- Living Wall at Victoria University Wellington.
- Green walls at Westfield Newmarket.
- Hundertwasser Wairau Māori Arts Centre in Whāngārei.
- The Wellington Water Sensitive Urban Design Guide provides more information on green walls.





Raised building platforms or land

PARA category:

Accommodate

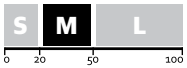
Hazards addressed:



Cost:



Timeframe:



Building and/or resource consent:



Land for buildings and infrastructure is raised to be above expected future flood levels and/or potential landslide runout areas. Materials commonly used to raise land include engineered fill material or raised concrete slabs. Land can be raised for individual building or infrastructure when newly built or upgraded, or for whole subdivisions based on flood modelling.

Benefits:

- Can increase design life, value, saleability and insurability of the building.
- Provides flexibility to adapt to future changes – can increase development yield.
- Potential amenity benefits (eg improved views due to higher elevation).

Limitations:

- Can incentivise further development in exposed areas which might increase future risk and reduce flexibility to adapt to future changes.
- Potentially high embodied carbon emissions (eg depending on materials and methods used to fill in land).
- Reduced natural infiltration from heavily compacted fill.
- Potentially reduced access to building during flood (if road access is not raised).
- Only suitable for new greenfield developments where raised ground levels will not impact adjacent properties.
- Can limit ability for waterways to naturally respond to flooding and increase velocities within constrained channels.

Examples:

- Weka St Nelson .
- Glen Dowie wastewater pump stations were dry mounted following the Auckland Anniversary floods.

Elevated buildings

PARA category:

Accommodate

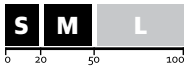
Hazards addressed:



Cost:



Timeframe:



Building and/or resource consent:



Buildings that can accommodate flood waters, ie water is allowed to enter and exit the building, encouraging a more natural flow of water during flood events. This can be done by lifting the structure above flood levels (eg on poles or piles) and/or creating floodable basements (also called sacrificial ground floors) using flood damage resistant building materials, installing vents and ensuring service infrastructure is located above flood levels. Implementable for new builds or existing service infrastructure where feasible to elevate on timber piles so that habitable floor level is raised above expected flood level.

Benefits:

- Can increase design life, value, saleability and insurability of the building.
- Able to be retrofitted where existing buildings are able to be raised (light weight timber frame).
- Requires no extra land.
- Potentially low embodied carbon emissions (eg through reuse/recycling of materials).
- Alternative to managed retreat in areas of widespread shallow inundation.

Limitations:

- Costs borne by owner, which might increase inequalities.
- Potentially reduced access to building during flood.
- Takes time for the building stock to be renewed, ie widespread implementation takes time.
- Might require further incentives (eg rates rebates) or regulations (eg district plan rules) for widespread uptake.
- Can incentivise further development in exposed areas which might increase future risk and reduce flexibility to adapt to future changes.

Examples:

- Papakāinga Ngātiawatanga concept design for the Kōkōhīnau Papakāinga Trust.
- Te Wananga o Raukawa – Campus buildings on elevated piles above modelled flood levels (see photo below).



Te Wananga o Raukawa

Garden improvements/landscaping

PARA category:

Accommodate

Hazards addressed:



Cost:

$ $$ $$$

Timeframe:

S **M** L

0 20 50 100

Building and/or resource consent:



Installation of small-scale drainage solutions on private properties and gardens to retain, detain and better control runoff during small to moderate events. Solid garden structures, notably fencing can act like a dam. Design fencing and other structures to avoid interrupting natural drainage patterns. Placing fences parallel to drainage flow if possible, not perpendicular and/or use holes, breaks or open fences such as slatted or lattice type fences where positioned in overland flow paths. Could include works to divert and/or temporarily store water, such as swales, surface drains, soakage trenches, and no mow lawns. These can direct stormwater flows into green spaces across the property, supporting vibrant greenspaces while reducing the volume of runoff. Where appropriate could include disconnecting downpipes to discharge to garden beds where this will not cause problems with adjoining properties. Permeable fencing (open spaces for water flow) across overland flow paths will reduce risk of uncontrolled floodwaters being deflected into properties where damage may occur.

Benefits:

- Relatively easy to install by homeowners.
- Provides wider ecosystem services (eg water filtering, water storage, nutrient accumulation).
- Emissions are likely to be low, depending on materials used.
- Provides flexibility to adapt to future changes.

Limitations:

- Requires space on property.
- Requires ongoing maintenance.
- Costs borne by owner, which might increase inequalities.
- Could contribute to nuisance overland flow paths or landslips where not considered within wider landscape context.
- May damage plants not suited to increased water.
- Limited benefits for larger magnitude events.

Examples:

- Downspout Disconnection program in Portland Oregon.
- No mow lawns to increase water holding capacity.





Adaptation Options

General infrastructure

Increase capacity and durability of existing built infrastructure

PARA category:

Accommodate

Hazards addressed:



Cost:

$ **$$** $$$

Timeframe:

S **M** **L**

0 20 50 100

Building and/or resource consent:



Adaptation should not focus solely on new interventions or infrastructure, maintenance and renewal of existing assets play an important role too.

Upgrade, repair, or replace critical infrastructure – such as energy, telecommunications, transport, waste, and social services – to withstand and recover quickly from climate-related disruptions. This includes raising vulnerable components (eg electrical outlets and wiring) above flood levels, using water-resistant materials like stainless steel to reduce corrosion, providing waterproof housing for vulnerable assets, expanding the capacity of existing pipe networks, undergrounding overhead power lines, and removing redundant or unused infrastructure. These measures ensure that essential systems remain functional and resilient throughout their design life, even as extreme weather events become more frequent.

Benefits:

- Increase design life, value and insurability of infrastructure.
- Increases reliability of provision of services, especially during and after events.
- Can attract further development and economic growth in surrounding areas.

Limitations:

- Significant installation, upgrading and maintenance works.
- Potential impacts on neighbouring properties (eg through diverting of flood waters, visual impacts, noise).
- Can incentivise further development of buildings and infrastructure in exposed areas, potentially increasing future risk.
- Might require additional land and/or change in land use, leading to a loss of current land uses and potentially habitats and species, including taonga species, ecological connectivity and species migration.
- Potentially high embodied emissions through use of heavy machinery and materials such as concrete.

Examples:

- Wairau Road substation in Auckland, built in 2013 to withstand a 1 in a 450 year flood, remained fully operational during the Auckland Anniversary floods in 2023 despite 1.5m of water flowing through it.
- Transpower substation flood risk mitigation programme.

Regrading of road cross sections

PARA category:

Accommodate

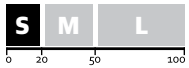
Hazards addressed:



Cost:

$ | $$ | $$$

Timeframe:



Building and/or resource consent:



Roads are major impervious surfaces that collect stormwater and are often located in flood-prone areas, especially along historic piped waterways. Traditional road design uses a raised crown that slopes toward footpaths and adjacent properties, which can worsen flooding impacts and allow vehicles to push water into buildings. Regrading road cross sections so water is contained between kerbs can help detain and slow floodwaters or allow higher flow rates without overtopping the road corridor. While some sections may become impassable during floods, this approach reduces damage to nearby properties and speeds recovery. These works should be integrated with land-use planning strategies, such as overland flow path management. to identify the best locations for controlled overland flow paths in roading corridors and short term water storage within the roading network.

Benefits:

- Enables accommodation of flood waters in existing built up areas without impact on private properties.
- Can be integrated with other road upgrade projects to reduce costs.
- Can ensure road corridor can still accommodate emergency vehicles and/or public transport at increasing levels of rainfall.
- Can increase value, insurability and saleability of land and houses in low risk areas.

Limitations:

- Requires co-ordination between Council teams
- Can reduce the Level of service for roads during moderate flood events.
- Need to consider pavement design and ground conditions to ensure resilience of pavement.
- May necessitate designation of alternative routes during flood events.
- Can incentivise further development in exposed areas which might increase future risk and reduce flexibility to adapt to future changes.



Source: Morphum Environmental
Renders: Tom Greer

Examples:

- Queen Street Richmond, Tasman District.
- Copenhagen cloudburst strategy includes the use of roads as major water holding and conveyance routes to protect private property.

Optimised infrastructure operation and management

PARA category:

Accommodate

Hazards addressed:



Cost:

$	$$	$$$

Timeframe:

S	M	L

0 20 50 100

Building and/or resource consent:



Management of infrastructure and building works that account for weather and climate impacts (eg improved monitoring, revised works and maintenance schedules, operating rules of plants, timing of earthworks, creation of disaster mitigation plans, or strategic planning for climate impacts).

Managing infrastructure effectively means being responsive to forecasted weather and climate impacts. This involves real-time monitoring, proactive maintenance schedules, detailed event response plans, and collaboration with other councils and utilities. Advanced technology—such as cameras and AI—can help detect blockages, monitor local rainfall intensity for drainage networks, forecast when and where floods are likely to occur and trigger timely interventions. Well-resourced maintenance programmes and knowledge sharing ensure systems remain functional and resilient, reducing disruption and enabling faster recovery during extreme events.

Benefits:

- Potentially increases asset/ design life and reliability of provision of services.
- Does not require physical changes to the asset or the environment.
- Provides flexibility to adapt to future change.
- Improved warning capabilities enabling faster more effective emergency responses.

Limitations:

- Might require change in how infrastructure is currently being managed and installation of monitoring and early warning systems.
- Potential reduction of access during and after events.
- Increase in operational costs (OPEX).

Examples:

- Infrastructure operation and management.
- National Vulnerability Assessment of Aotearoa New Zealand's Critical Infrastructure.
- WCC Transport criticality analysis to determine maintenance ahead of heavy rainfall.
- Piha's Flood Management System pilot.



New sludge minimisation plant in Wellington

Adaptation Options

Stormwater infrastructure

Centralised pump stations

PARA category:

Accommodate

Hazards addressed:



Cost:

$ | $$ | $$$

Timeframe:

S | M | L

0 20 50 100

Building and/or resource consent:



Centralised pump stations remove water from flooded areas and pump it to designated water bodies at a neighbourhood or sub catchment scale. They are permanently installed and can function automatically if coupled with an automatic float switch. They tend to be part of a wider municipal flood defence system (eg when combined with natural floodplains).

Benefits:

- Do not require significant land area. Can be retrofitted into existing networks
- Easy operation through automated systems.

Limitations:

- Need multiple pumps throughout catchment to provide meaningful benefits.
- Expensive to install and operate with need for significant pump rates. Requires ongoing maintenance and testing to ensure readiness.
- Can be vulnerable to power outages during storm events. May impact on amenity (eg noise during operation).
- Can incentivise further development in exposed areas which might increase future risk.
- Potential increase in embodied (eg through use of concrete) and operational emissions (eg through use of non-renewable energy).
- Limited benefits for larger magnitude events due to limited capacity.

Examples:

- Stormwater Pump Station in Waimakariri District.
- Karehana Park flood relief pump station in Plimmerton.
- Taranaki Street Rising Main project.
- Portobello Road Pump Station in South Dune.



Taranaki Street Pump Station construction



Flood pump

Water sensitive urban design (WSUD) in redevelopment

PARA category:

Accommodate

Hazards addressed:



Cost:

$ | $$ | $$$

Timeframe:

S | M | L

0 20 50 100

Building and/or resource consent:



Brownfield development occurs on previously developed land with opportunity to improve on existing situation and progressively ensure climate change adaptation is improved in existing urban areas. Current best practice and policy supports the implementation of water sensitive design principles and techniques in the planning and construction of any new development including redevelopment.

This provides an opportunity for infill development to integrate new stormwater management devices that can treat both the development site and areas around and upstream of it. WSUD is based on Principles to manage and treat all rainfall runoff to ensure resilience to current and future climate whilst supporting healthy ecosystems and vibrant communities. This can be achieved through adopting an integrated water approach which incorporates hydrologic controls, water quality treatment, flood detention and increased pervious green space.

Benefits:

- Using redevelopment of existing urban areas to improve outcome.
- Aligned with Regional rules and best practice across New Zealand.
- Opportunities to incorporate best practice stormwater management, including nature-based elements (eg raingardens, green roofs etc).
- Can increase value, insurability and saleability of surrounding buildings.
- Can integrate into landscape, providing additional treatment to surrounding road catchments and roofs.
- Can integrate knowledge of Wellington's piped stream network to enhance mauri of the waterways.

Limitations:

- Incremental improvements over long time scale due to pace of individual developments.
- Increased costs to developers and property owners due to need to comply with new provisions, which might increase inequalities.
- Need to ensure long term maintenance including cross agency collaboration and from private residents associations.

Examples:

- The Wellington Water Sensitive Urban Design (WSUD) Guide sets out the city's approach to water resource management in urban environments, integrating natural water systems with built form and landscape.
- Hobsonville Point development.
- Auckland Manukau Eastern Transport Initiative – major Auckland busway with fully integrated water management.









Existing stormwater infrastructure management and upgrade

PARA category:

Accommodate

Hazards addressed:



Cost:

$ | $$ | **$$$**

Timeframe:

S | **M** | **L**

0 20 50 100

Building and/or resource consent:



Upgrade and maintain existing stormwater infrastructure to be able to increase its capacity (eg such as larger pipes for stormwater, wider modified stream channels) and linkages with other infrastructure such as centralised pumping and water quality treatment. This decreases the likelihood of overtopping and flooding, and increases the resilience and reliability of the stormwater system. Where increased capacity is not feasible, modelling should define the expected level of service and communicate this with community and other key parties.

Benefits:

- Can attract further investment and economic growth in surrounding area.
- May increase amenity values and recreational opportunities, especially if paired with nature-based solutions (eg tree pits).
- Able to be undertaken with less land requirements.
- Can be integrated with other catchment wide initiatives such as flood detention.
- Easily understood by Engineering industry.
- Opportunity to improve fish passage through piped streams.

Limitations:

- May not pass full peak flows (1% AEP) and therefore need to be used in combination with other works.
- Significant installation, upgrading and maintenance costs borne by Council, which may lead to increase in rates.
- Limited benefit where sea level rise or shallow groundwater will limit the capacity of pipes.
- Need to consider the ecological connections through piped streams and the ecological values of existing modified streams.
- Needs to be designed as part of a catchment wide programme to avoid making problems worse downstream of improvements.
- Challenges with conflict with existing below ground infrastructure.
- Can incentivise further development in exposed areas, which might increase future risk.
- Increase in embodied and/or operational emissions, eg through use of concrete, plastic or steel for construction.



Examples:

- Bridge to Better Nelson.
- Pinehaven Stream Improvements (Upper Hutt) to provide capacity in the stream for a 1 in 25 year return period flood event, including by building of retaining walls in built up areas and widening of stream where there is space.
- Up to date information on Wellington Water projects underway. Stormwater renewals and improvement programme.

Public flood detention infrastructure

PARA category:

Accommodate

Hazards addressed:



Cost:

$	**$$**	$$$

Timeframe:

S	**M**	L

0 20 50 100

Building and/or resource consent:



Public flood detention integrated with useable public space through creating multi-use spaces which can serve as flood detention during infrequent large rainfall events and public recreation/amenity at other times. This can significantly reduce costs for adaptation (as do not need procurement of new land) and enable community spaces to provide multiple benefits. Examples include flood detention above well positioned sports fields. floodable assets like skateparks/ hard courts or wider landscapes formed to accommodate temporary ponding during large rainfall events.

Benefits:

- Low cost when considered alongside wider redevelopment of public space.
- Enables active use of flood detention areas for majority of time when not needed for storage.
- Detention areas easily reinstated following rainfall as long as wastewater not an issue.
- Allows for increased community engagement and connection with water systems.
- Can increase amenity which can raise value and saleability of nearby properties.
- Costs for reinstating sports fields is likely to be less than costs of flooding. emergency responses.

Limitations:

- Retrofit sites can be limited in urban environments.
- Need to ensure no lasting damage from short term detention (ie rehabilitated sports fields).
- Need to ensure public/ community awareness of infrequent flood detention (signage).
- Need to be aware of design for safety where structures are classified as 'Dams'.

Examples:

- Flood detention bund in Liadet Street Park Berhampore.
- Te Oranga Waikura Urban Forest and Stormwater Basin (Christchurch).
- Greenslade Reserve (Auckland).



L.airdet St Park bund in Berhampore (left) and examples of Dry Detention Basins (3 others)

Wastewater inflow mitigation

PARA category:

Protect

Hazards addressed:



Cost:

$ | **$$** | $$$

Timeframe:

S | **M** | L

0 20 50 100

Building and/or resource consent:



Wastewater overflows often occur where excessive stormwater is able to flow into the wastewater network during storm events which exceed the design capacity of the wastewater pipes causing overflows. This can be through illegal stormwater connections. private gully traps in flood prone land or wastewater manholes in OLFP or flood areas. Inflow to the wastewater system can cause uncontrolled wastewater overflows resulting in contaminated flood waters increasing public health risks and condemning of flooded properties.

Mitigation can be complicated by the scale and extent of wastewater networks and typically requires raising ingress points such as gully traps, wastewater manholes and pump stations in combination with educating property owners/ tradesmen on the role of gully traps and importance of separating stormwater from the wastewater network. Catchment scale investigations and enforcement to find incidence of stormwater entering the wastewater network is difficult due to the ingress only occurring during heavy rainfall.

Benefits:

- Reduce potential contamination in standing flood waters.
- Relatively easy to target ingress points in flood prone areas.
- Relatively low tech solutions (elevate gully traps and/or seal problem manholes).
- Reduces flow to wastewater treatment plants, meaning less untreated overflow into receiving environments.
- Cultural benefits where contaminated floodwaters could contact food growing. urupā or other sensitive sites.
- Can be combined with other flood mitigation techniques to remove or address standing water.

Limitations:

- Pipe and manhole condition is often unknown making project scope difficult to define.
- Raising/shifting manholes can be difficult.
- Does not address groundwater entering wastewater pipes through broken/damaged pipes.

Examples:

- Water NZ Technical guidelines to support catchment scale investigations.



A compliant downpipe

Separate from a gully trap and connects to the stormwater pipes on your property.



A non-compliant downpipe

Connects to a gully trap so the stormwater will enter the wastewater pipes.

Overland flowpaths management

PARA category:

Accommodate

Hazards addressed:



Cost:

$	$$	$$$

Timeframe:

S	M	L

0 20 50 100

Building and/or resource consent:



Overland flow paths refers to the routes taken by water where there is no engineered drainage network or the network is blocked. Overland flow path management involves the identification and creation of flow paths (eg within road corridors, or through private properties), and the management and maintenance of these routes to avoid obstruction to flow. This includes the clearing of obstructions such as buildings, fences or other structures, as well as finding space for and widening floodplains to ensure water can flow freely without causing harm until it reaches a drain, stream or the sea. Flow paths need to be kept clear to be effective but can be a combination of formal public land (eg roadway kerb and channel) or private properties (driveways and space between buildings). Permeable fencing (eg raised above ground, slatted or lattice) can be used when required across overland flow paths but require ongoing and proactive maintenance to avoid blockage. Need to be careful that any changes to overland flow paths do not adversely impact adjacent properties through diverting water from the natural flow path.

Benefits:

- Cost effective minor works can have significant benefits.
- Can enable moderate flows to pass safely through built up areas.
- Easily understood and modelled to enable identification of problem areas.
- If planted, flow paths can create habitats for flora and fauna, including taonga species, provide ecological corridors and enhance amenity and recreational opportunities.
- Provide flexibility to adapt to future changes.

Limitations:

- Might require access to and utilisation of private and public properties, and hence coordination of multiple stakeholders (eg councils, NZTA, hapū/iwi, residents, community groups).
- Potential health hazard if stormwater quality is poor.
- Requires ongoing monitoring and maintenance to keep flow paths clear.
- Can be hard to communicate importance to homeowners
- Limited benefits for larger magnitude events.
- Often unsuited to address larger scale peak flooding due to limited capacity of urbanised overland flow paths.

Examples:

- Auckland Council Overland Flow Path Programme.



Coastal Inundation (Medium Hazard Area)

Coastal Inundation extent - with 1.43m sea level rise and 1:100 year storm

Coastal Inundation (High Hazard Area)

High Coastal Inundation

Inundation (Low Hazard Area)

Overland Flowpath (Medium Hazard Area)

Suburb Labels

Wellington City Boundary

Adaptation Options

Nature-based solutions

Dune restoration

PARA category:

Protect

Hazards addressed:



Cost:

$ | $$ | **$$$**

Timeframe:

S | **M** | L

0 20 50 100

Building and/or resource consent:



Restoration of dunes such as through the installation of barrier fencing, dune reshaping and planting indigenous species such as spinifex and pīngao. These plants catch windblown sands during storm events and trap it to build and maintain the dunes. Dunes can help absorb wind and wave energy, reduce coastal erosion and create a natural buffer between the sea and land, protecting the coastal hinterland from flooding.

Benefits:

- Low cost and rapid.
- Can maintain and restore natural habitats for flora and fauna, including taonga species.
- Can enhance natural character, mauri, and access to the natural environment, including wāhi tapu (eg mahinga kai).
- Mātauranga could be used to guide the restoration process (eg the type of plant, practices for dune preservation such as selective harvesting of plants).
- Provides flexibility to adapt to future change.
- Can act as a carbon sink.

Limitations:

- Can require additional space and might impede on current uses of coastal areas.
- Can be a barrier to beach access
- Requires ongoing maintenance including of access ways to maintain dune health.
- Limited protection to long-term sea-level risk and storm surges unless space for dunes to migrate inland.

Examples:

- Dune restoration in Lyall Bay and Island Bay.





Lyall Bay dunes

Increased pervious surfaces

PARA category:

Accommodate

Hazards addressed:



Cost:

$ | **$$** | $$$

Timeframe:

S | **M** | L

0 20 50 100

Building and/or resource consent:



Pervious or permeable surfaces and porous paving allow water to pass through to the underlying soil layers to slow and reduce the volume of runoff and localised flooding. Two distinct types include porous paving that stormwater travels through (e.g. porous concrete or asphalt) and permeable paving where stormwater travels through the gaps between impervious blocks. Alternatively, underutilised paved areas of road corridors or other paved surfaces can be deconstructed and converted into urban greenspaces. Mainly used for low-impact transport infrastructure (eg driveways, parking lots, footpaths, walkways etc) or for increased garden beds around street trees or pocket gardens. Increased planting of canopy street trees can effectively intercept small rainfall events and provide shading of paved areas beneath to reduce impacts of urban heat to communities and downstream receiving environments.

Benefits:

- Can maintain existing use (for car parking) while supporting shallow infiltration.
- Can improve water quality by filtering contaminants out of stormwater and increases groundwater recharge.
- Can support robust and healthy urban street trees.
- Potentially low embodied emissions if appropriate materials are reused (e.g. recycled tyres to make porous paving).

Limitations:

- May not be suited for heavy traffic and may have a shorter design life than nonpermeable pavings.
- Requires ongoing proactive maintenance.
- Potential high embodied and/or operational emissions, e.g. through use of concrete, plastic or steel.
- Limited benefit in large rainfall events due to soakage rates in subgrade.
- Can be unsuited to some pavements where subgrade is not able to accommodate infiltration.
- Limited benefits for larger magnitude events due to limited capacity.

Examples:

- The Wellington Proposed District Plan requires at least 30% of residential sites to have permeable surface (able to absorb water).
- The Wellington Water Sensitive Urban Design Guide provides more information on permeable/porous paving.
- Porous Laliile permeable paving from recycled tyres (Watersmart) – see photo.



Pervious pavement around trees along Wellington's waterfront

Stream daylighting

PARA category:

Accommodate

Hazards addressed:



Cost:

$ | $$ | **$$$**

Timeframe:

S | **M** | **L**

0 20 50 100

Building and/or resource consent:



This option brings previously buried/piped waterways back to the surface and into restored environments. Daylighting can increase the area available for water to pass, increasing storage capacity which can reduce peak flowrates and increase flow duration. This helps to reduce downstream and localised flooding. Typically combined with riparian planting and floodplain restoration to support ecological benefits.

Benefits:

- Creation of natural habitats for flora and fauna, including taonga species, enhanced ecological connectivity (fish passage) improved water quality, cooling effects.
- Can enhance natural character, mauri (eg maintain water flows for important puna (springs) and awa (streams and rivers) and the connection and access to natural environment, including wāhi tapu (eg mahinga kai).
- Increased amenity, recreational opportunities and mental wellbeing by providing green spaces.
- Mātauranga could be used to guide the restoration process (eg the identification of original stream locations and native flora and fauna, design of restoration process).
- Can increase flood conveyance capacity and storage within landscape.
- Can act as carbon sink.

Limitations:

- Design is critical to ensure it reduces flood risks.
- Requires land area to create naturalised waterway corridor.
- Can be complicated by the depth of existing piped streams
- Water quality in streams will be degraded until such time as catchment wide stormwater management implemented.
- Slopes cut for streams may experience instability and streams may cause instability of existing slopes.
- Requires ongoing maintenance and pest management.
- Potentially significant costs to create space (eg purchase land) and physically daylight streams as well as to coordinate multiple stakeholders.

Examples:

- Houghton Valley – Lifting the Creek.
- La Rosa Stream in Auckland – stream daylighting project through public reserve.
- Te Ara Awataha in Auckland.



Waitangi Stream impression



Stream restoration

PARA category:

Accommodate

Hazards addressed:



Cost:

$ | **$$** | $$$

Timeframe:

S | **M** | **L**

0 20 50 100

Building and/or resource consent:



Stream restoration can restore urbanised or channelised waterways into a more natural form. This involves increasing the area available for water to meander and managing grade changes that cause erosion and mobilisation of sediment. This helps to improve downstream stormwater quality and eliminate the risk of localised flooding due to reduced capacity. Typically combined with riparian planting and floodplain restoration.

Benefits:

- Creation of natural habitats for flora and fauna. including taonga species, enhanced ecological connectivity, improved water quality, cooling effects.
- Can enhance natural character, mauri (eg maintain water flows for important puna (springs) and awa (streams and rivers) and the connection and access to natural environment, including wāhi tapu (eg mahinga kai).
- Mātauranga could be used to guide the restoration process (eg the identification of original stream path and native flora and fauna, design of restoration process).
- Increased amenity, recreational opportunities and mental wellbeing by providing green spaces.
- Initial costs can be mitigated with community support (eg planting days), low costs in the long term (easy maintenance once plantings are established). Can increase property values in surrounding areas.
- Can act as carbon sink.

Limitations:

- Requires space and potentially repurposing of land in urban areas.
- Can be limited by unmanaged stormwater discharges.
- Potential health hazard if stormwater quality is poor.
- Requires ongoing maintenance and plant management, and physically daylight streams as well as to coordinate multiple stakeholders.

Examples:

- Waitangi Stream. Paiiawai Reserve, Wellington. Project to restore degraded stream and increase resilience to stormwater inputs.
- Waiwhetū Stream in Wellington – the Waiwhetū Stream a restoration partnership: Water New Zealand.



Upper Waitangi Stream restoration



Pinehaven st retaining wall and stream divider



Waihetu Stream

Living shorelines

PARA category:

Protect

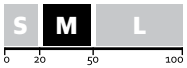
Hazards addressed:



Cost:



Timeframe:



Building and/or resource consent:



Active planting of shorelines (including rocky coastal sections, turf fields etc) to create a barrier between land and sea, potentially combined with other natural materials such as rocks to support plant growth. They can act as natural buffers for these environments and increase their ability to absorb and dissipate wave energy.

Benefits:

- Costs can be reduced with community support (eg planting days).
- Can maintain and restore natural coastal habitats for flora and fauna, including taonga species (eg banded dotterel, little penguin).
- Can help reduce drought and temperature fluctuations in coastal areas.
- Can enhance natural character and mauri.
- Mātauranga could be used to guide the restoration process (eg the type of plants and other materials to use and choice of locations).
- Can increase amenity and recreational opportunities.
- Provides flexibility to adapt to future change.
- Can act as a carbon sink.

Limitations:

- Takes time for plants to establish.
- Requires ongoing monitoring, maintenance and pest management.
- Can be a barrier to beach access and coastal views, and hence decrease amenity values, recreational opportunities.
- Can struggle to support future climate events (storm surge) due to rising sea levels.

Examples:

- Planting of rocky shore plants and restoration of coastal turf fields on Taputeranga Island, Houghton Bay and around the South Coast.
- Tātou ki Uta Coastal Reserves Management Plan.



Oruaiti Reserve

Rain gardens/Bioretention

PARA category:

Protect

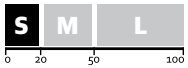
Hazards addressed:



Cost:



Timeframe:



Building and/or resource consent:



Vegetated area constructed with specific soil and filter layers and select indigenous plants designed to detain, retain and filter stormwater flowing from impervious surfaces, such as roads, pavements and driveways. After filtration, water will flow into internal storage/infiltration or existing stormwater pipes. Raingardens can integrate easily into urban landscapes and provide efficient stormwater treatment for a range of contaminants while providing additional ecological services. Well suited to include element of detention for small to moderate rainfall events and/or retention through infiltration from the base or connection with stormwater harvesting.

Benefits:

- Relatively low cost to install.
- Creates natural habitats for flora and fauna, including taonga species.
- Provides wider ecosystem services such as increased water quality, groundwater recharge, air quality filtering and temperature regulation.
- Mātauranga could also be used to guide the construction process (eg the type of plants).
- Can enhance the connection and access to natural environment, including wai.
- Increased amenity, visual impacts, recreational opportunities and mental wellbeing through green spaces in the city.
- Provides flexibility to adapt to future changes.
- Can act as a carbon sink.

Limitations:

- Can be relatively expensive depending on site constraints.
- Needs available space in location that water can easily drain to.
- Requires ongoing monitoring, maintenance and pest/weed management which will incur additional costs. Might require further incentives (eg rates rebates, public education) or regulations (eg district plan rules) for widespread uptake.
- Potential embodied emissions (eg through use of concrete for kerbs). Limited benefits for larger magnitude events due to limited capacity.

Examples:

- Rain gardens in Swan Lane and Garrett Street.
- The Wellington Water Sensitive Urban Design Guide provides more information on rain gardens.



Swan Lane rain garden

Riparian planting

PARA category:

Accommodate

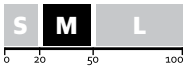
Hazards addressed:



Cost:



Timeframe:



Building and/or resource consent:



Planting and maintenance of native species along the banks of rivers, streams, drains, wetlands, lakes or ponds to stabilise banks, slow down water flows and decrease risk of erosion. Can also help to stabilise toes of slopes and reduce landslide risk where water flows close to steep hills. Can be combined with other riparian stabilisation techniques such as toe rock armour, grade controls and catchment stormwater management.

Benefits:

- Low costs, can be reduced with community support (eg planting days).
- Increased amenity and recreational values.
- Creates natural habitats for flora and fauna, including taonga species, on land and in the water. Provides further ecosystem services such as improved water quality.
- Can enhance natural character and mauri.



Restored Kaiharawhara Stream with a healthy riparian plant coverage. Image courtesy of Steve Attwood – Auldwood Birds

- Mātauranga can be used to guide the planting process (eg the successional planting of different species at different stages of the year).
- Relatively easy and low cost to install and maintain.
- Provides flexibility to adapt to future change.
- Can act as carbon sink.

Limitations:

- Costs associated with initial site preparation, planting, maintenance, restoration (eg if plants washed away during floods) and weed/pest management, but costs can be partly mitigated with community support (eg planting days, maintenance and pest management).
- Requires consent of landowner, potential access issues on private land (could be mitigated by placing covenants on land).
- Takes time for plants to grow and maximise stabilisation effects.
- Need specific plants to ensure they do not destabilise banks or restrict flood flows.

Examples:

- Wellington City Council Stream Restoration Planting Guide
- The Wellington Water Sensitive Urban Design Guide provides more information on riparian buffers.

Seaweed restoration

PARA category:

Protect

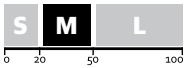
Hazards addressed:



Cost:



Timeframe:



Building and/or resource consent:



Restoration of seaweeds on the seafloor can act as a natural form of coastal protection. It can reduce wave action and energy, in particular in shallow waters, reducing the strength and size of waves before they reach the coast. It is noted that methods such as the creation of Marine reserves can achieve similar outcomes through the establishment of robust and diverse seaweed communities.

Benefits:

- Can maintain and restore natural marine habitats for flora and fauna, including taonga species.
- Provides wider ecosystem services such as water filtering, more stable marine temperatures and diversity of habitats.
- Can enhance natural character and mauri.
- Mātauranga could be used to guide the restoration process (eg the types of seaweeds and choice of location).
- Can increase amenity and recreational opportunities (eg diving, fishing).
- Can increase productivity of local fisheries and seaweed production.
- Can act as carbon sink.

Limitations:

- Limited benefit in exposed deep water/open coast (south coast).
- Can be very difficult to implement properly, requires a lot of knowledge around specific species and where to best locate seaweed beds.
- Takes time for plants to establish.
- Costs for initial planting and ongoing maintenance.
- Requires monitoring, maintenance and pest management.
- Can impede current use of the sea.

Examples:

- Love Rimu-rimu – Regenerating Wellington's Underwater Forests.
- Operation Crayweed – Restoring Sydney's Underwater Forests.



Vegetated swales

PARA category:

Accommodate

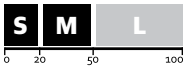
Hazards addressed:



Cost:



Timeframe:



Building and/or resource consent:



A landscaped vegetated channel that helps filter stormwater and enables it to infiltrate into the soil or disposal into the stormwater system. Swales generally work best on gentle slopes that allow the plants to have more time to influence the water. Swales can either be simple vegetated systems or constructed with specified filter materials, underground drains and selected plants (bio-swale). Swales should be well vegetated (suitable indigenous species) with underdrains and/or check dams depending on slope.

Benefits:

- Creation of natural habitats for flora and fauna, and provision of wider ecosystem benefits, such as improved water quality.
- Can reduce the size of downstream water quality treatment devices (such as wetlands).
- Mātauranga can be used to guide the planting (eg type of plants).
- Can act as carbon sink.

Limitations:

- Limited water quality benefits due to being exposed to high flows.
- Costs for installation and maintenance (eg to prevent the accumulation of sand, silt and mud and debris such as leaves that could block drains).
- Requires space, which may be difficult and costly to obtain in highly urbanised areas.
- Changes in rainfall patterns may cause the system to become less effective.
- Limited benefits for larger magnitude events due to limited capacity.

Examples:

- The Wellington Water Sensitive Urban Design Guide provides more information on swale.
- Water Sensitive Design for Stormwater: Treatment Device Design.



Planted swales

Vegetating hills and slopes

PARA category:

Accommodate

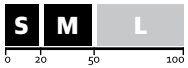
Hazards addressed:



Cost:



Timeframe:



Building and/or resource consent:





Forest in the Heart of Wellington project planting in Tawatawa Reserve

Hills and slopes that are vegetated with suitable vegetation (indigenous trees, shrubs and ground covers) can help to slow down and filter rainfall runoff, minimise erosion potential and stabilise slopes from slumping and shallow landslides. Can be used on natural or engineered slopes (e.g. where cuts have been made to create roads) and is often used as part of restoration of currently weed infested hillsides on public and private land.

Benefits:

- Creates natural habitats for flora and fauna, including taonga species, on site and in downslope environments, as well as further environmental co-benefits (eg filtered water, clean air, temperature regulation).
- Supports ecological corridors and reduces habitat fragmentation.
- Can enhance natural character and mauri, especially if native species used.
- Mātauranga could be used to guide vegetation (eg the types of plants and successional planting of different species at different stages of the year).
- Increased amenity, visual impacts, recreational opportunities and mental wellbeing.
- Can increase value of surrounding land and properties.
- Aligns with wider aspirations and targets for revegetation.
- Relatively easy to implement and maintain at a low cost.
- Can act as carbon sinks.

Limitations:

- May not be enough to prevent landslides under all conditions.
- Costs for initial planting and ongoing weed/pest management, but costs can be mitigated with community support (eg planting days).
- Requires space on public or private property.
- Requires proactive maintenance and pest/weed management. Especially during establishment.
- Can increase wildfire risk, need to consider species selection in proximity to dwellings.

Examples:

- Forest in the Heart of Wellington project.
- Auckland's Urban Ngahere (Forest) Strategy.

Constructed wetlands

PARA category:

Accommodate

Hazards addressed:



Cost:

$	$$	$$$

Timeframe:

S	M	L

0 20 50 100

Building and/or resource consent:



An engineered shallow-water environment that provides treatment and storage of stormwater and/or tidal flows in a series of shallow pools that are planted with riparian (growing along riverbanks or lake edges) or emergent vegetation (rooted underwater but sticking up above the surface). Depending on design and storage capacity, can provide protection through buffering of flows during frequent small or more infrequent medium/large rainfall events that are retained in the wetland and released slowly.



Constructed wetland at Waitangi Park, Wellington



Te Kukuwai o Toa

Benefits:

- Creates habitats for flora and fauna, including taonga species.
- Provides wider ecosystem services such as improved water quality on site and in downstream environments by filtering out nutrients, sand, mud, silts and microbes such as E.coli.
- Costs can be mitigated through community involvement (eg for planting, regular maintenance and pest control).
- Low maintenance once established.
- Can enhance natural character and mauri.
- Mātauranga could be used to guide the restoration process (eg the type of plants, the location of wetland).
- Can increase amenity, recreational opportunities and value of surrounding land and properties.
- Provides flexibility to adapt to future change.
- Can act as a carbon sink.
- Cost effective where available space enables treatment of large catchments.
- Readily integrated with flood detention.

Limitations:

- Careful selection of species required to ensure plantings survive and mature. Significant installation and maintenance costs, but costs can be partly mitigated with community support (eg planting days, maintenance and pest management).
- Requires a lot of space and time to fully restore to a self-sustaining wetland.
- Limited benefits for larger magnitude events due to limited capacity unless able to design with flood detention.
- Requires careful design to ensure water quality treatment functions as intended and reduce the presence of bugs/ mosquitos.
- Requires ongoing monitoring and maintenance.

Examples:

- Constructed wetland at Waitangi Park.
- The Wellington Water Sensitive Urban Design Guide provides more information on constructed wetlands.

Natural wetlands: restored or preserved

PARA category:

Accommodate

Hazards addressed:



Cost:

$	$$	$$$

Timeframe:

S	M	L

0 20 50 100

Building and/or resource consent:



Wetlands are permanently or intermittently wet areas that support natural ecosystems that can reduce the impacts of flooding. Preserving existing or restoring former natural wetlands along coasts and rivers with indigenous species reinstates natural water table levels and flows as well as floodplains, allowing them to absorb heavy rain and release water gradually. Wetlands also help stabilise shorelines and riverbanks.



Restored wetland within Kāpiti's Queen Elizabeth Park

Benefits:

- Can restore natural habitats for flora and fauna, including taonga species.
- Provide wider ecosystem services such as improved water quality on site and in downstream environments by filtering out nutrients, sand, mud, silt, and microbes such as E.coli.
- Can enhance natural character, mauri and the connection to natural environment, including wāhi tapu (eg mahinga kai).
- Mātauranga could be used to guide the restoration process (eg where wetlands originally existed, soil health or the appropriate plants to use).
- Can increase amenity, recreational opportunities and mental wellbeing through providing natural open spaces.
- Can increase value of surrounding land and properties.
- Can reduce the risk of wildfires.
- Low maintenance once established, and a very long life span (>100 years).
- Provides flexibility to adapt to future change.
- Can act as carbon sink.

Limitations:

- Very few remaining natural wetlands in Wellington.
- Limited benefits for larger magnitude events due to limited flood capacity.

Examples:

- Te Reo o Te Repo: The Voice of the Wetland is a handbook that highlights a range of mahi (work) undertaken by iwi (tribes) and hapū (sub-tribes) to increase the health and wellbeing of their repo (wetlands).
- Tangaroa Awa wetland, Owae marae, Taranaki – Restoration of wetland through marae grounds for ecological and cultural values.

Wind breaks and planting barriers

PARA category:

Accommodate

Hazards addressed:



Cost:

$ | $$ | $$$

Timeframe:

S | M | L

0 20 50 100

Building and/or resource consent:



Vegetation can provide a barrier to strong winds, redirecting gusts around buildings or deflecting them upwards away from doors or windows. These barriers are especially important at the edges of development or neighbouring large open areas as they experience relatively higher speeds. Wind strength and predominant direction can come from discussions with neighbours, the shape and condition of existing vegetation, and the surrounding topography. This determines the optimal location for the planting. These barriers work best when using single row wind breaks of the same species for consistency, arranged to deflect wind but allow some air flow to prevent turbulence on the leeward side.

Benefits:

- Increased shelter and amenity space around the building.
- Reduced wind loads on the structure.
- Lower noise levels.
- May increase property value, saleability, and insurability.
- Creation of natural habitats for flora and fauna.
- Mātauranga could be used to guide the selection of hardy wind resistant species.
- Initial costs can be mitigated with community support (eg planting days).
- Can act as carbon sink.

Limitations:

- Careful selection of species required to ensure plantings survive and mature.
- Costs for installation are borne by owner, which might increase inequalities.
- Most effective at the subdivision level as buildings and wind breaks can be designed to shelter each other.
- Individual barrier can redirect wind into neighbouring properties.
- Can result in loss of sunlight or block neighbouring views.

Examples:

- BRANZ Bulletin – Managing Wind Effects around buildings.
- MBIE Resilient homes – wind and storms.



Wind barrier – Aotea Pond

Adaptation Options

Hard protection/ structural approaches

Breakwaters and artificial reefs

PARA category:

Protect

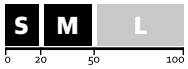
Hazards addressed:



Cost:



Timeframe:



Building and/or resource consent:



A structure made of rocks or concrete, built parallel or perpendicular to the coastline to reduce wave energy at the coast and control along shore drift. This reduces erosion and can create less turbulent conditions on coastal edge. They can be above or below sea level, where the latter may be referred to as artificial reefs.

Benefits:

- Can increase recreational opportunities by building up beaches and providing low wave energy areas.
- Can create new habitats for marine species (eg artificial reefs).

Limitations:

- Impacts to seabed and kaimoana during and after construction.
- Might reduce amenity (eg visual impacts) and recreational opportunities such as by changing surf conditions.
- Can incentivise further development in exposed areas which might increase future risk and reduce flexibility to adapt to future changes.
- Construction materials might be difficult to source.
- Limited effectiveness in Wellington's deep water beaches, eg south coast
- Potentially high embodied emissions depending on materials used.

Examples:

- Lyall Bay breakwater.
- Oriental Bay artificial reef.



Oriental Bay artificial reef



Breakwater blocks at Seaview Marina in Wellington Harbour

Slope Stabilisation/Retaining walls

PARA category:

Protect

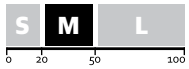
Hazards addressed:



Cost:

$ $$ $$$

Timeframe:



Building and/or resource consent:



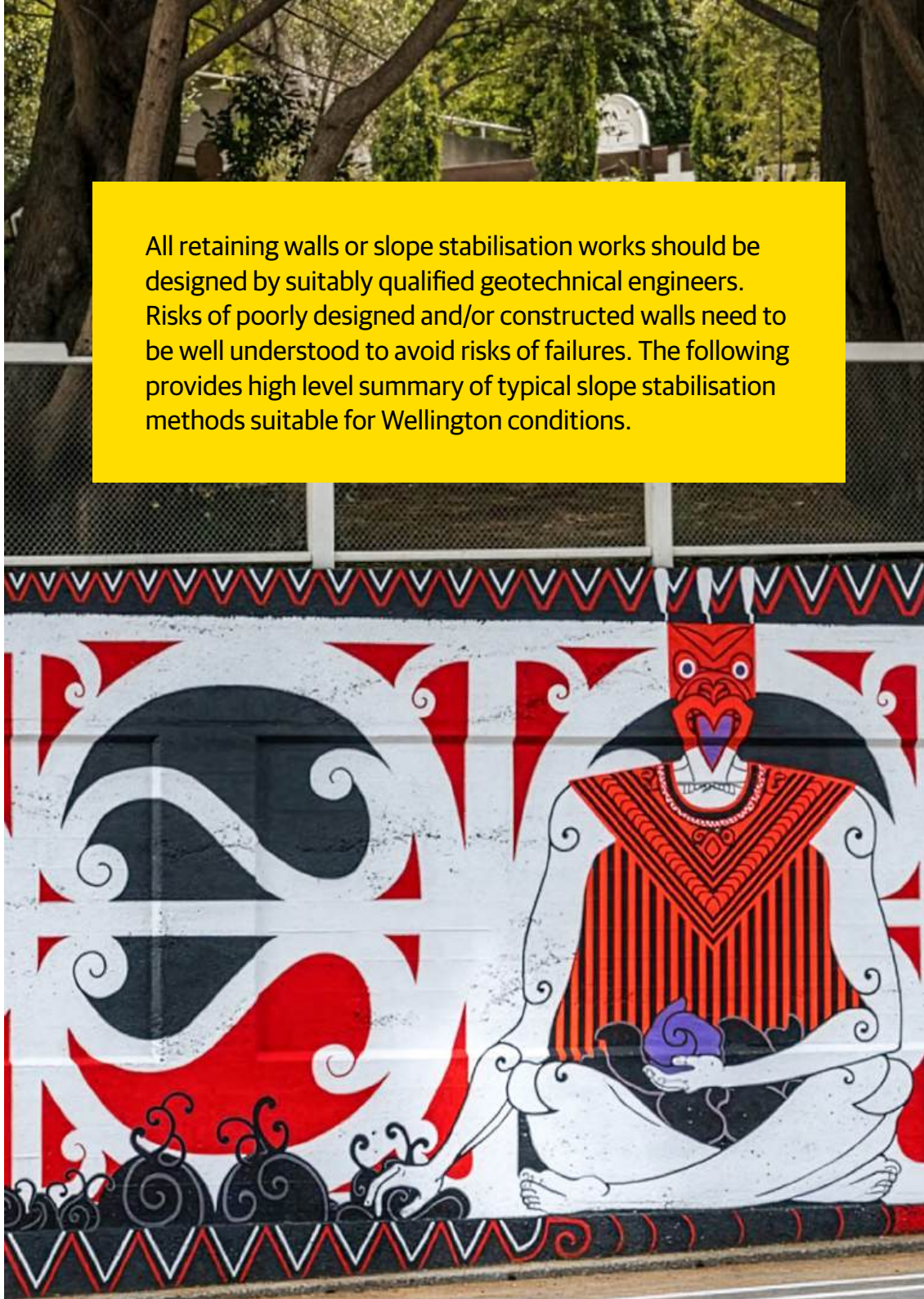
The topography and historical development patterns across Wellington result in many steep and potentially unstable slopes which are prone to landslides. These include landslides on private property and public land where it may impact buildings, transport routes, buried infrastructure and environmental outcomes from sediment discharge. Landslides can be caused by a complex mix of conditions including the underlying geology, historical earthworks (such as cut to fill roads), removal of vegetation and seismic events. Climate impacts such as prolonged droughts causing tension cracks, high intensity rainfall and tree falls exposing sub soils can increase the risk of landslides. Typically, landslide risks require bespoke engineered works to stabilise and hold unstable slopes based on careful geotechnical design. Designs will vary based on site soils, height, risk and accessibility for construction. A range of retaining wall types and/or slope stabilisation are used throughout Wellington to retain steep slopes adjacent to roads or on private residential properties. Other options such as building set-backs, zoning or other controls may also be required pending the cost and complexity of slope stabilisation.

Benefits:

- Able to be retro fitted where space allows.
- Might maintain property/ land values, saleability and insurability.

Limitations:

- Often limited by access, particularly for private properties built against steep slopes.
- Can be expensive due to complex geology and need for geotechnical design.
- On private property, costs usually borne by owner, which might increase inequalities.
- Risk of damage from earthquakes (esp for older retaining walls).
- High embodied emissions if concrete or similar and/or imported materials used.
- Can reduce amenity and increase rainfall runoff.



All retaining walls or slope stabilisation works should be designed by suitably qualified geotechnical engineers. Risks of poorly designed and/or constructed walls need to be well understood to avoid risks of failures. The following provides high level summary of typical slope stabilisation methods suitable for Wellington conditions.

Timber pole retaining walls

Timber retaining walls are typically used to retain steep slopes at varying heights. Design is based on the deep embedded poles providing the structural strength with the spacing and therefore length of boards supporting the slope material. Design needs to consider the height of the retained slope, any loadings from structures or active loads (such as roads) and accessibility to construct. Typically require deep footings for poles (mechanically bored), treated timber poles concreted in place and secured timber retaining boards behind. Often combined with ground anchors (particularly where walls are high) and groundwater drainage (either drilled into face or installed directly behind wall). Timber pole walls can be stepped up a slope with multiple smaller walls where geotechnical design permits. Any wall over 1 metre will require a building consent and may require hand railing at top.



Gravity retaining walls

Gravity retaining walls work through the mass/weight of the structure withstanding the force from the slope. These will generally not include a deep piled footing (although this can be included in design if needed) and therefore are supported by gravity alone. The angle of the retaining wall and the type of material used need to be designed based on the specific conditions. Examples of gravity retaining walls include concrete/timber crib walls, gabion walls and bespoke precast concrete block walls. Gravity walls can be suited to difficult to access sites (such as behind houses) where access for heavy bore hole equipment may be difficult.



Cast in-situ/block walls

Cast in-situ walls are formed through the use of reinforced concrete walls or reinforced, concrete filled concrete block walls. These can be suited to localised situations where retaining walls are to be integrated with other structures (such as buildings directly adjoining steep slopes). Walls need to be designed with appropriate footings and can include ground anchors.



Spray concrete walls

Spray concrete is often used to create a structural cover over unstable slopes, often in response to landslides once they have occurred. Typically, reinforced concrete (includes steel or other fibres in mix) is sprayed into steel mesh which is draped over trimmed face of slope to be retained. Finished slope can remain more undulating when compared with structural or gravity walls which are more uniform. Can be combined with drilled ground anchors to tie sprayed surface to face with groundwater drainage needed through face to reduce risks of pressure build up. Spray concrete walls can be lower cost but can have limited amenity and increase the amount of stormwater generated through increasing imperviousness. Quicker to install than more structural walls and can be suited to sites with poor access.









Ground anchors

Ground anchors are mechanically drilled into slopes (often a considerable distance) and grouted in place to create a friction force to bind unstable slopes and 'tie' retaining walls to the slope. The depth of the anchor needs to consider the local geology, expected failure mechanisms and integration with other retaining measures on site. Following grouting, anchors are mechanically tensioned through pulling the head of the anchor out from the slope at a nominated force and then fixing a secure plate on the face of the wall that holds the tension. Ground anchors are well suited to be combined with timber pole walls, cast in situ walls, spray concrete and rock mesh. Installation of ground anchors is a highly specialised trade requiring careful design and installation.

Terracing

Steep slopes can be managed through excavated terracing or benches which are cut to form steps to reduce the vertical height of each steep cut face. These can be cut into rock faces or formed in engineered compacted fill with the dual benefit that earthworks machinery can progressively cut down high slopes working off terraces. Terracing is often seen on major cut rock faces such as highway cuttings or as part of remediation of large scale landslides and has limited applicability on constrained slopes around Wellington. Benches on terraced face will often include surface drains to prevent uncontrolled flow over cut faces and overall design may be integrated with localised spray concrete (for fault inconsistencies etc), ground anchors and groundwater drainage. Terracing can also be achieved with steeped retaining walls which is considered more of a wall design.



Groundwater drainage

Groundwater can be a contributing factor in slope instability and needs to be accommodated in any slope stabilisation works to prevent build up of pressure. Groundwater discharge from slope is generally a natural occurrence which in natural conditions would be manifest as seepages or headwater springs that discharge shallow groundwater from uphill land and often form the headwaters of streams or forest wetlands and can vary throughout the year or in response to climate. Excavation of slopes, or development of upstream land, can modify the position or amount of seepage which are often viewed as a nuisance/problem rather than a natural occurrence.
In some situations, groundwater can move across fractured rock fissures and can contribute to slope failures where changes such as bush clearance or earthworks have changed conditions. Leakages from uphill buried infrastructure (including mains water, wastewater or stormwater) can be misrepresented as groundwater and may cause slumping and slope failures that need to be addressed at the source of the leak. Equally, uphill stormwater management that include infiltration/soakage of all or part of the urban runoff needs to be carefully understood in terms of potential implications for downslope instability. Groundwater drainage can comprise stepped works to capture seepage behind solid walls and convey it via perforated/solid pipes to the stormwater network or drilled drains which extend into the slope and directly discharge down the face of spray concrete or rock cut faces.



Rock netting

Rock netting/mesh is used to reduce the risk of rocks dislodging from cut slopes rather than stabilising the overall slope itself. Ground anchors or soil nails are fixed with mesh extending over all or part of a slope. Mesh includes flexibility to catch rock fall or minor slips and contain them behind the mesh to avoid material impacting roads, buildings or other spaces that could cause damage to people or property. Rock netting needs to be robust enough to contain the size and weight of material dislodged and needs specialist design for the anchors, tie wires and mesh. Typically requires maintenance to remove accumulated material and to inspect for damage.



Mechanically Stabilised Earth (MSE) structures

MSE structures are typically constructed with compacted engineered fill which is reinforced with high tensile strength geogrids mesh anchors. These are generally used for the construction of new steep slopes (often to create building platforms) but can be used in retrofitted retaining walls where space allows such as alongside roadways. Can be used in streamside retaining walls with planting incorporated into the face.



Bio-engineering

Nature based retaining structures can provide an effective means of retaining lower risk slopes or combined with other more structural retaining systems to add additional amenity and biodiversity. Careful consideration is needed to ensure that any bio engineering will provide an appropriate level of stability in consideration of the size, steepness, soils and site-specific landslide triggers. Options such as planting species selected for root strength into graded slopes can provide cost effective support for lower risk sites but require ongoing maintenance where trees may need to be hedged. This can provide stability to roadside cut faces which are often destabilised by the lack of deep rooted plant species. Planting into MSE walls, terraced slopes or other retaining walls needs to be agreed with geotechnical designers to ensure that the walls' stability is not compromised.



Sea walls

PARA category:

Protect

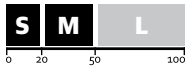
Hazards addressed:



Cost:

$ | $$ | $$$

Timeframe:



Building and/or resource consent:



Engineered structures along the coastline with the purpose to deflect wave energy and/or protect the coastal hinterland from storm surges and waves. Seawalls are usually made of concrete, boulders or steel sheet piles, but can also be made of other materials such as wood, aluminium, fiberglass or biodegradable sandbags. Used where coastal erosion is threatening critical infrastructure (such as roads) or private property which is likely to increase as a result of sea level rise.

Can be designed to support coastal ecosystem through consideration of habitat for kororā, lizards and marine species. Important to design any seawalls (and other coastal structures) with an informed understanding of coastal processes and the potential for hard structures to cause unintended scour and erosion on adjacent coastal areas or scour of beach/cobbles at toe of walls.

Benefits:

- Can increase recreational opportunities by stabilising public spaces adjacent to otherwise eroding coastline.
- Can create new habitats for marine species (eg artificial reefs or integrated habitat features).
- Can reduce exposure of contaminated material where historical fill has been placed adjacent to the coast.





Ecological kete-like tiles being attached to the new rock embankment at the southern end of Te Whanganui-a-Tara (Wellington Harbour)

Limitations:

- Impacts to seabed and kaimoana during and after construction.
- Expensive to construct and consent due to coastal environment.
- Can cause increased erosion on adjacent land from deflected energy.
- Limited protection for storm surge on top of long term sea level rise.
- Might reduce amenity (eg visual impacts) and recreational opportunities such as by changing surf conditions.
- Need to consider impact of rising sea levels causing undercutting and loss of intertidal zone/beach.
- Can incentivise further development in exposed areas which might increase future risk and reduce flexibility to adapt to future changes.
- Lack of large size rock in local quarries necessitating import of rock from further afield.
- Potentially high embodied emissions depending on materials used.

Examples:

- Te Ara Tupua .
- Tahitai shared path and coastal resilience project
- Island Bay seawall.

Adaptation Options

Strategic and land use planning

Building and development standards

PARA category:

Accommodate

Hazards addressed:



Cost:

$ | $$ | $$$

Timeframe:

S | M | L

0 20 50 100

Building and/or resource consent:

N/A



In New Zealand, building codes, district plan rules, and urban growth strategies need to integrate climate resilience to reduce exposure to hazards such as flooding, coastal erosion, and landslides. This includes requirements like coastal and river setbacks under the Resource Management Act (RMA), minimum floor levels for flood-prone areas, robust drainage and stormwater systems to manage heavy rainfall, and structural specifications to withstand seismic and wind loads. Councils may also apply shorter consent durations or managed retreat/relocation provisions in high-risk zones. Updating these standards ensures new developments align with national climate adaptation priorities and local hazard management plans.

Benefits:

- Opportunities to incorporate sustainable building practices, including nature-based elements (eg raingardens and green roofs).
- Can increase value, insurability and saleability of new and upgraded houses.
- Can increase design life of new and upgraded developments.
- Provides flexibility to adapt to future change.
- Opportunity to integrate emission considerations into design.

Limitations:

- Benefits not felt until medium term due to delays in implementation.
- Only applies to new houses, significant upgrades and redevelopments but does not reduce risk to existing houses.
- Increased costs to developers and property owners due to need to comply with new provisions, which might increase inequalities.
- Potentially lengthy plan change processes, delayed implementation.

Examples:

- The Wellington District Plan requires hydraulic neutrality for more intensive developments (eg through rainwater retention), at least 30% of a residential site to have a permeable surface, and for water sensitive design methods to be incorporated into larger developments (four or more units and non-residential development).
- The Wellington Water Sensitive Urban Design (WSUD) Guide sets out the city's approach to water resource management in urban environments, integrating natural water systems with built form and landscape.

Resilient service routes

PARA category:

Accommodate

Hazards addressed:



Cost:

$ | $$ | $$$

Timeframe:

S | M | L

0 20 50 100

Building and/or resource consent:



Extreme weather events like floods, storm surges, and landslides can disrupt roads, public transport and essential services. making it harder for communities to stay connected during and following emergencies. To keep people safe and moving, potential to strengthen key transport routes and lifeline services, provide resilient alternatives, and share information on backup travel options. As climate change increases the risk of disruption, proactive planning, community awareness, and investment in stronger infrastructure are essential. Possible to build a more resilient network that helps everyone respond and recover quickly when it matters most.

Benefits:

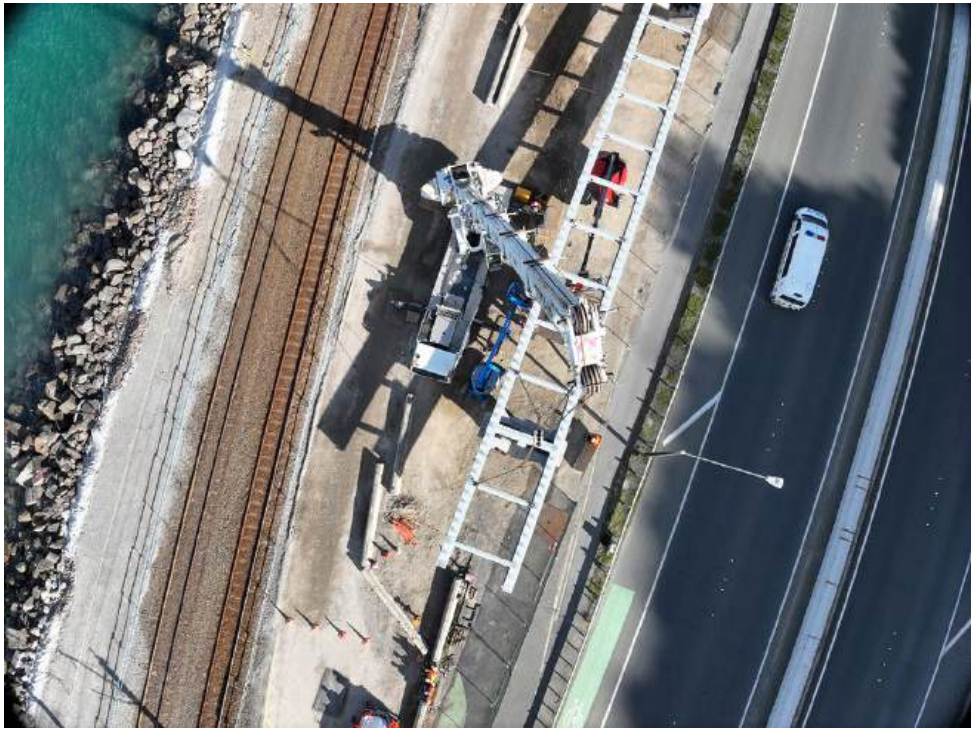
- Increased community resilience to a range of events.
- Can ensure access to hospitals and emergency evacuation routes during emergency scenarios.
- Ensure access to critical assets to ensure faster re-instatement of essential services during emergencies.
- Enables communities to react during and after climate events without elevated risk or social dislocation.
- Supports mindset of embedding adaptation and monitoring into decision making frameworks for climate event response.
- Reduces risk of communities from being isolated without necessary services.

Limitations:

- Requires high level of community engagement and outreach.
- Potential high costs to protect and stabilise identified emergency transport routes which may ordinarily carry low traffic volumes
- Requires understanding of slope stability and infrastructure condition on identified emergency transport routes.
- May not be practical to maintain public transport services on emergency transport routes due to grades and/or narrowness.

Examples:

- Wellington High Traffic Routes Map.
- National Disaster Resilience Strategy.



Pro-active strategic relocation

PARA category:

Relocate/ Retreat

Hazards addressed:



Cost:

$ $$ **$$$**

Timeframe:

S **M** **L**

0 20 50 100

Building and/or resource consent:

N/A

Māori and other indigenous peoples have long histories of placing infrastructure outside of high-risk areas and relocating in response to natural hazards. Pro-active strategic relocation involves planning, zoning and implementing measures to remove houses, other buildings and infrastructure away from areas of high current or future risk. This can include public acquisition of vulnerable land through voluntary or mandatory buyouts, land swaps, housing setbacks, leasebacks, future interests, conservation easements, or transferable development rights, followed by repurposing these areas – such as for recreational or nature reserves with integrated adaptation measures such as constructed wetlands or coastal dunes. Can support transformative change to communities whereby climate related risks are mitigated whilst providing enhanced biodiversity, urban ecology and public recreation opportunities. Can be coupled with other adaptation options (such as elevated building) to support resilient development immediately adjacent to land cleared of development. Identifying low-risk land safer places to move to is essential.

Benefits:

- Can eliminate risk to life, buildings and infrastructure in high risk areas.
- Long timeframes allow time for deliberation and planning to occur to ensure beneficial outcomes, including for future generations.
- Opportunity for community to shape new neighbourhoods with access to improved housing, services (health, education) and environmental benefits (eg blue-green infrastructure, reserves, lower emissions).
- Opportunity to re-naturalise origin area to create natural habitats for flora and fauna and enhance mauri.
- Mātauranga could be used to guide the retreat process (eg definition of triggers, signals and thresholds, identification of low risk areas to move to, monitoring of conditions).
- Potential to re-use materials and integrate emission considerations into new developments and create carbon sinks in original area.

Limitations:

- Requires significant upfront investment by government, landowners, businesses, infrastructure providers and potentially other organisations (like insurers and banks).
- Potential loss of cohesion, cultural identity, wāhi tapu, wellbeing, sense of place and belonging.
- Potential to perpetuate impacts of colonisation such as land loss.
- Requires coordination of all those affected with well run planning processes based on meaningful engagement.
- Takes a lot of time.
- Currently lack of national guidance, policy mechanisms, processes, funding and implementation support for the implementation of successful retreat.
- Likely to require plan changes and resource and building consents, together with strengthening of legislation.
- Not flexible once retreat process started (due to investment in infrastructure).

Examples:

- Project Twin Streams purchased and removed properties to reduce the risk of flood damage and make stream banks more accessible for restoration planting.
- Māori and other Indigenous peoples have rich histories of relocations, utilising their own Indigenous knowledge, local implementation, and adaptability to natural hazards.
- Managed retreat as one strategic area of the Ka Mate Kaainga Tahi, Ka ora Kaainga Rua the Ngaa Rauru Kiitahi climate change strategy.



Restoration planting



Relocating a house

Re-active relocation

PARA category:

Relocate/ Retreat

Hazards addressed:



Cost:

$ | $$ | **$$$**

Timeframe:

S | **M** | L

0 20 50 100

Building and/or resource consent:

N/A



Christchurch Red Zone

Reactive relocation refers to the withdrawal, removal, or relocation of people, private property, and public assets in response to an immediate threat or after a hazard has already occurred. This typically happens through emergency evacuations during disasters or through post-event measures such as buyouts following severe damage or insurance withdrawal buyouts when properties become uninsurable. Unlike proactive relocation, reactive relocation often occurs under urgent conditions, leaving little time for planning and resulting in significant damage to homes, infrastructure, and community assets. While necessary for safety, it can be highly disruptive and costly, highlighting the importance of preparedness and long-term resilience strategies to reduce reliance on reactive measures.

Benefits:

- Opportunity to re-naturalise origin area to create natural habitats for flora and fauna and enhance mauri.
- Potential to re-use materials and integrate emission considerations into new developments and create carbon sinks in original area.

Limitations:

- Lack of time to plan can lead to potential loss of livelihoods, housing, infrastructure, sovereignty, cultural identity, wāhi tapu, sense of belonging and community.
- May disproportionately affect vulnerable communities and limit ability for just and flexible adaptation response.
- Significant costs for emergency response.
- Potential impacts to papakāinga and connection to place for Māori.
- Contamination from flooded/ destroyed properties and assets.
- Compressed timeline and unstructured retreat process.
- Appropriate locations for resettlement might not be immediately available.
- Requires coordination between multiple stakeholders.
- Potential increase of emissions during emergency response and as limited reuse of materials from damaged houses and infrastructure.

Examples:

- Christchurch Red Zone.
- Auckland Council Category 3 Buy-out and Category 2P Risk mitigation scheme to buy out flood affected properties.



Restricting development/ activities in high-risk areas

PARA category:

Avoid

Hazards addressed:



Cost:

$ **$$** $$$

Timeframe:

S **M** **L**

0 20 50 100

Building and/or resource consent:

N/A

Restricting future development in high-risk areas means identifying locations vulnerable to current or future climate hazards and limiting activities that could increase risk– such as subdivision, intensification, new developments, or social infrastructure. These restrictions are typically implemented through land-use planning tools like (re)zoning and prohibiting or limiting certain activities. This approach can be phased in over time as risk grows (for example, allowing only movable houses temporarily) or applied immediately following a hazard event. The goal is to reduce exposure and prevent long-term vulnerability in areas where climate impacts are expected to worsen.

Benefits:

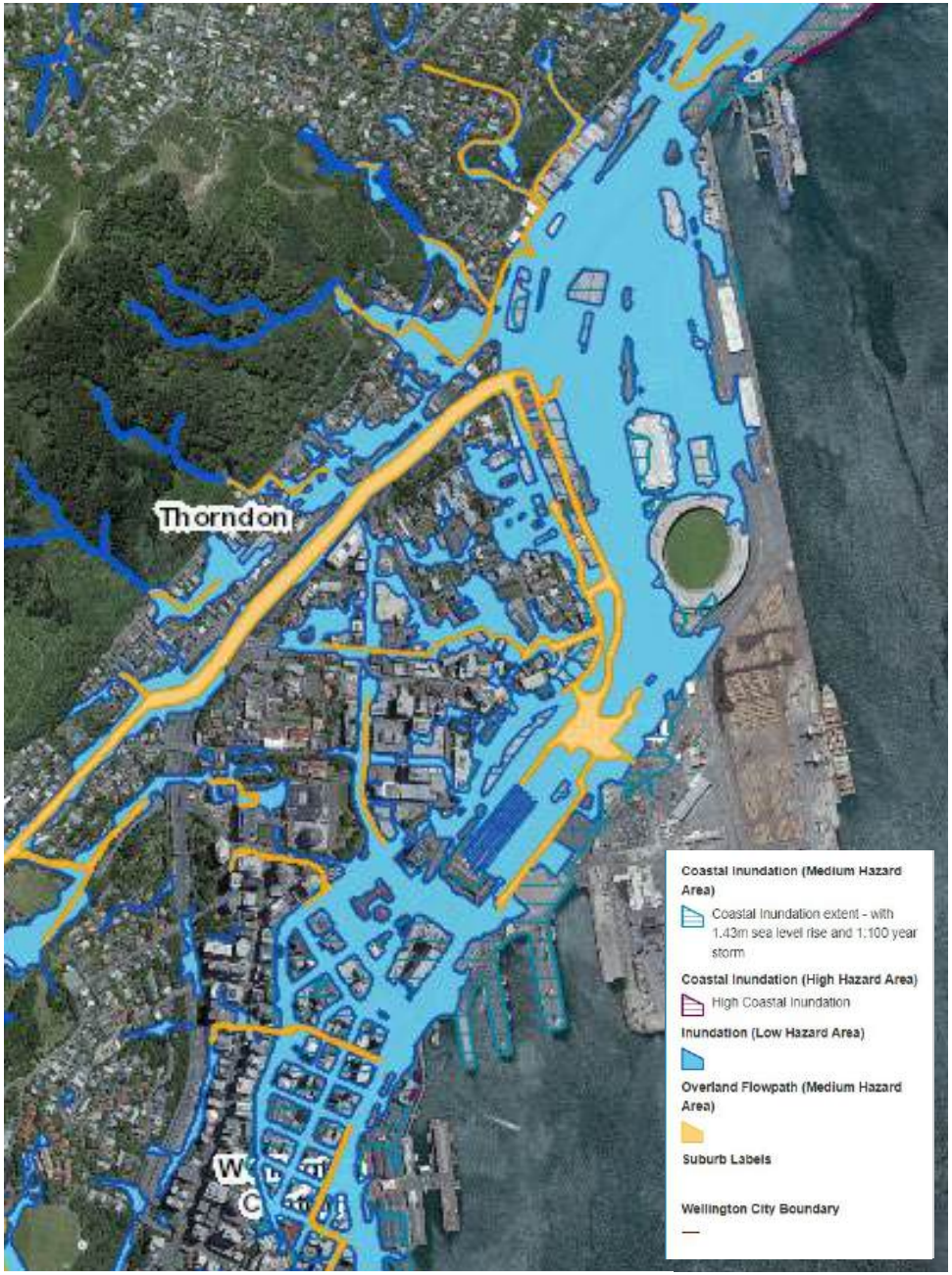
- Can increase value, insurability and saleability of land and houses in low risk areas.
- Costs for plan development and changes usually within normal council budgets.
- Opportunity to enhance environment and te mauri o te taiao (eg by rezoning land as open space or conservation land).
- Mātauranga could be used to guide the planning process (eg identification of areas and sites of cultural significance/wāhi tapu at risk and appropriate responses).
- Increase health and wellbeing through new recreational opportunities.
- Provides flexibility to adapt to future change.
- Reduction in emissions through avoidance of new developments and opportunity to integrate emission considerations into design.

Limitations:

- Often long planning processes with hearings and legal challenges.
- Impacts not felt until medium term as it takes time for the building stock to renew.
- Might lead to loss of insurability, saleability and property values in high risk areas, potentially increasing inequalities.

Examples:

- The Wellington District Plan places restrictions on building in high-risk areas (eg restricts the building of new sensitive activities, such as schools, hospitals or residential housing).



Flooding and coastal inundation overlays in the 2024 District Plan

Spatial, growth and infrastructure planning

PARA category:

Avoid

Hazards addressed:



Cost:

$ **$$** $$$

Timeframe:

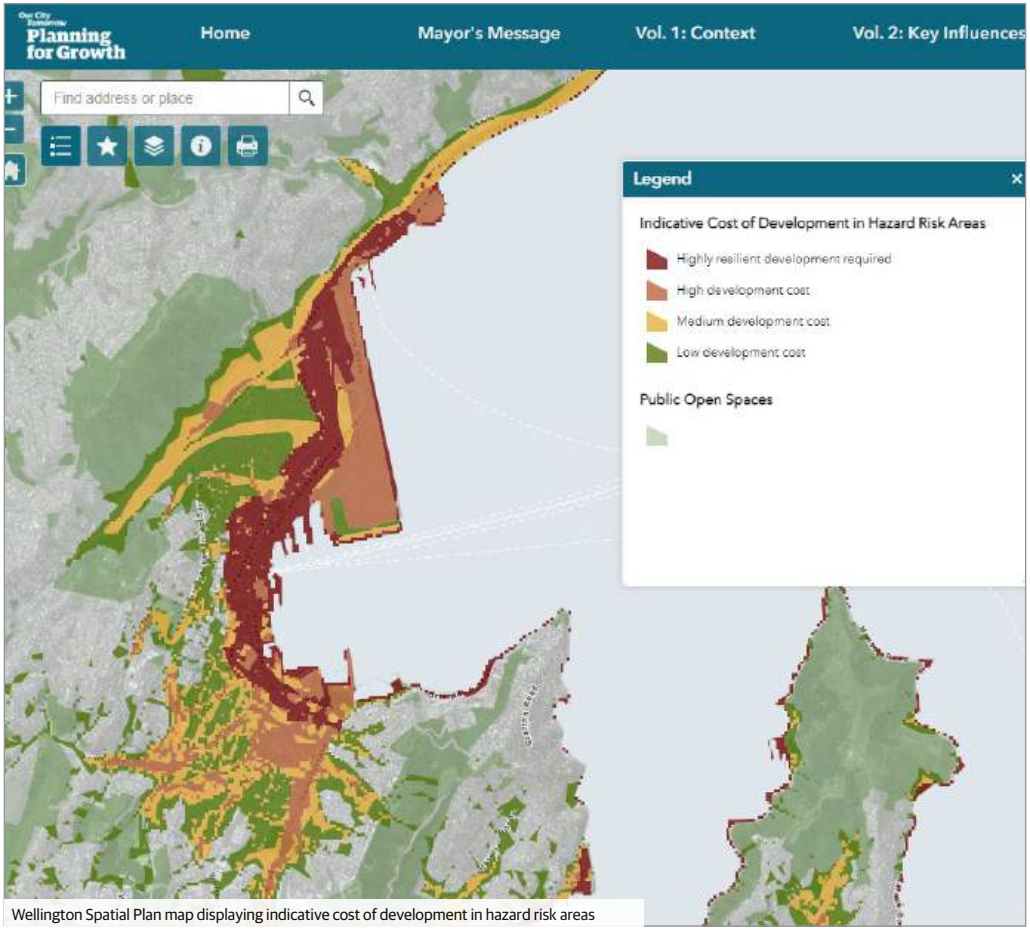
S **M** **L**

0 20 50 100

Building and/or resource consent:

N/A

Local and regional spatial, growth, and infrastructure planning helps determine where and how a city will develop over the medium term, using hazard and climate risk information to guide growth toward safer areas. These integrated plans bring together land use, transport, three waters, natural hazards, heritage, and environmental considerations to focus infrastructure investment, support urban development, and embed climate change adaptation. By identifying areas at current or future risk from natural hazards – including those intensified by climate change—these plans help highlight safer, more suitable locations for housing, business activity, and key infrastructure.



Wellington Spatial Plan map displaying indicative cost of development in hazard risk areas

Benefits:

- Takes an integrated, all hazards approach – combined with a broad focus on community aspirations and needs.
- Can direct development and activities away from areas at risk and/or identify appropriate actions to manage their future use dependent on the level of risk (eg modern building design).
- Can lead to increased and less costly development as well as higher house and land values and insurability in low risk areas.
- Community can provide input and shape the future of their city, with future generations in mind.
- Can help facilitate retreat discussions.
- Opportunity to enhance environment and te mauri o te taiao (eg by rezoning land as open space or conservation land).
- Mātauranga could be used to guide the planning process (eg identification of areas and sites of cultural significance/ wāhi tapu at risk and areas of high/low risk).
- Can enable living in papakāinga, and encourage cultural practices such as, tikanga and mātauranga Māori.
- Possibility to integrate emission considerations into new developments and city design (eg 15 minute city).

Limitations:

- Costs for spatial plan development and implementation.
- Might lead to decrease in land and house values and insurability in high risk areas.
- Might change the amenity and character of a city.
- Takes time to develop and implement spatial plan.
- Requires coordination of multiple stakeholders (including government agencies, business, local residents, iwi).
- Requires visionary political leadership and/or legislative direction.

Examples:

- Our City Tomorrow: Spatial Plan for Wellington City.
- Wellington Future – Development Strategy.
- 3 Waters Assessment to support spatial plan development.
- Maketu Climate Change Adaptation Plan He Toka Tu Moana Mo Maketu, includes as one of the actions Maketu spatial mapping and planning to show what Maketu might look like in 30–50 years time, in relation to climate change.

Adaptation Options

Community resilience initiatives

Community Emergency Preparedness and Response

PARA category:

Accommodate

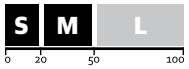
Hazards addressed:



Cost:



Timeframe:



Building and/or resource consent:



Community emergency resilience is about ensuring that neighbourhoods can prepare for, respond to, and recover from disasters effectively. It involves building local capacity through planning, resource sharing, and strong communication networks so communities can act quickly when hazards occur. Key elements include identifying risks, creating evacuation plans, having accessible early warning systems, establishing emergency hubs, and fostering partnerships with civil defence agencies. By empowering residents with knowledge and tools, communities become safer, more connected, and better equipped to withstand and bounce back from emergencies.

Benefits:

- Engages communities in discussions around emergency planning within their local area.
- Creates relationships between emergency response and community groups.
- Aligns with education, monitoring and nature-based solutions to enable engaged and informed communities.
- Allows vulnerable communities to be identified, and strategies formed to assist them.
- Establishes a central emergency hub to operate out of and provide resources to.
- Creates knowledge of local volunteers' knowledge and expertise ie First Aid, Cooking, Child Care etc.
- Creates prepared resilient communities.
- Enables efficient and effective post event recovery to limit disruption and maintain community morale.

Limitations:

- Buy in needed from large diverse communities, to ensure plan is comprehensive and effective.
- Emergency hubs need to be equipped with sufficient resources to support surrounding communities i.e. water tanks.
- Community need to be aware and accepting of risks and vulnerabilities in advance.

Examples:

- WREMO Wellington.
- Home - Get Ready (NZ Civil Defence) – Emergency preparedness in New Zealand.

Community public education activities

PARA category:

Accommodate

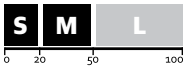
Hazards addressed:



Cost:



Timeframe:



Building and/or resource consent:



Well-informed communities are better able to adapt and respond safely to climate impacts. Raising public awareness of current and future climate change risks is essential for strengthening resilience. Public education should use a range of accessible formats and clearly explain climate risk; the likely impacts of climate events on specific locations; and practical guidance on how to prepare for, respond to, and recover from those events. This could include activities like:

- Information about hazards (eg online and on LIM reports)
- Emergency preparedness actions at home, within neighbourhoods, marae, community
- Early warning systems
- Community emergency response plans
- Business/organisation continuity plans
- Restricting access to public spaces where risks are intolerable
- Community monitoring programmes.

Together, these measures help ensure that communities not only understand the changing risk environment but are also equipped with the tools and information needed to respond proactively and safely.

Benefits:

- Opportunity to engage and inform communities of how their local catchment will respond to climate change and emergency events.
- Opportunities to gain mutual understanding and support for future projects which may require council/utility investments.
- Can enable communities to understand the climate risks they may not yet have personally experienced.

Limitations:

- Requires coordination with roles and responsibilities with government and other agencies.
- Education programmes require engagement and buy in from community members and groups.
- Can trigger resistance from communities where awareness may adversely impact property values.

Examples:

- Taranaki Whānui Maramataka Climate Change Monitoring Project.
- Te Ara o Raukawa Moana.
- Marae-led community emergency preparedness – Ngāti Toa o Rangatira, Nga Hau E Wha o Papararangi.
- WREMO emergency preparedness.
- WCC Climate Action Info Hub.
- Our Changing City installation.
- Neighbours Aotearoa.
- Auckland Council flood viewer for homeowners – Check for flood risks before you buy or build.



Educational signage

PARA category:

Accommodate

Hazards addressed:



Cost:

$	$$	$$$

Timeframe:

S	M	L

0 20 50 100

Building and/or resource consent:



Educational signage is an important tool for building community resilience to natural hazards. Clear, visible signs can guide people to evacuation routes, emergency hubs. and safe zones during floods. storms. or other extreme events. They also raise awareness about local climate risks and preparedness actions. helping residents and visitors understand what to do before and during an emergency. Using simple language, symbols. and multiple languages ensures everyone can access critical information. Reducing confusion and improving safety as climate hazards become more frequent and severe.

Benefits:

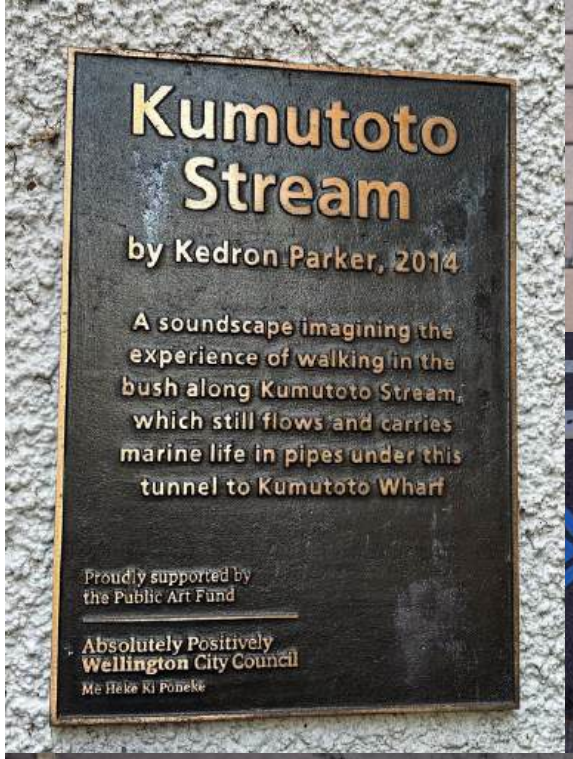
- Low-cost signage can provide education on historic flood levels, explain the purpose of infrastructure, or show what the land looked like prior to colonisation.
- Can combine with parks and reserves and wayfinding to inform community and visitors of the history of catchments.
- Opportunity to work alongside mana whenua to educate communities on sites of significance. place names and the reasons for these in a climate context.

Limitations:

- Effective signage requires engagement and buy in from community members and groups.
- Can trigger resistance from communities where awareness may adversely impact property values.

Examples:

- Wellington Region tsunami blue painted lines indicating areas for public safety.
- WCC hidden awa art showing historical awa that have since been piped.
- 1840 historic coastline plaques showing historic land reclamation.







Monitoring hazards and/or effectiveness of resilience actions

PARA category:

Accommodate

Hazards addressed:

Cost:

$ | $$ | $$$

Timeframe:

S | M | L

0 20 50 100

Building and/or resource consent:

unlikely — possible — likely

Monitoring is a critical component of climate adaptation resilience. ensuring that strategies remain effective as conditions change. It involves tracking climate hazards, infrastructure performance, and community vulnerability over time to identify emerging risks and evaluate the success of adaptation measures. Continuous monitoring allows planners and decision-makers to adjust policies, prioritise investments, and respond proactively to new challenges. By integrating real-time data, risk assessments, and feedback from communities. monitoring creates an adaptive system that supports long-term resilience and minimises the impacts of climate change.

Opportunities for citizen science can support increased awareness from communities and can provide important data to calibrate flood models and assess effectiveness of implemented adaptation options.

Benefits:

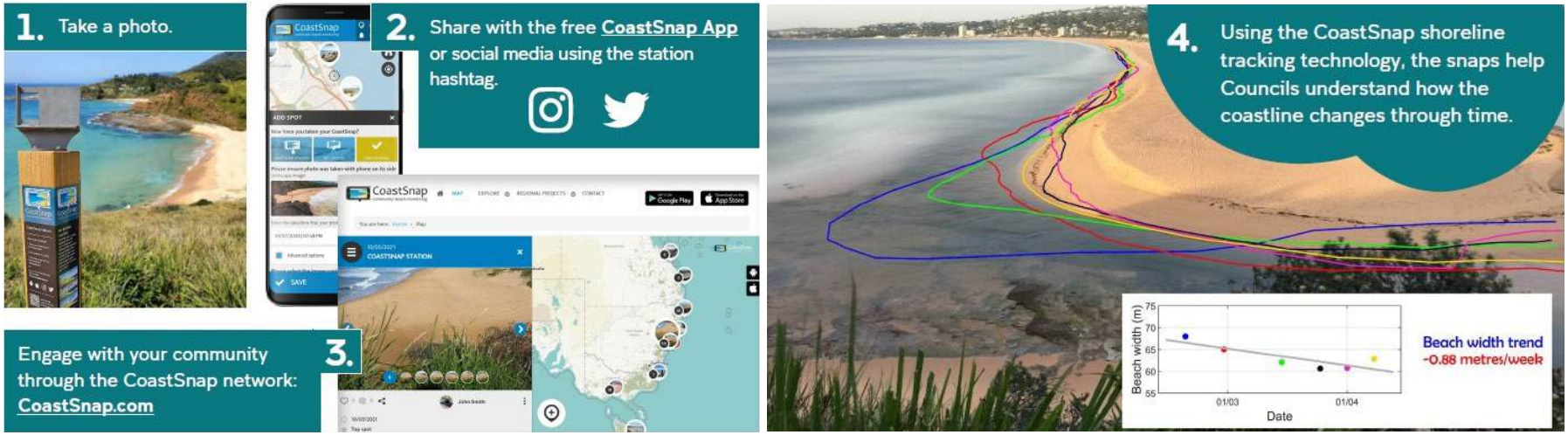
- Low capital cost for community-based initiatives.
- Can provide early warning system for significant climate events.
- Community involvement in monitoring can increase awareness and understanding of risks and potential solutions.
- Can utilise technology such as remote sensing and AI to monitor hard to access sites/ assets.
- Can provide knowledge of risk exposure. and how it changes over time.
- Opportunity to educate community members on what is going on in their local environment and train them on what to watch out for.
- Supports the integration of several unrelated systems (environmental monitoring, leasing, consenting, land use planning).

Limitations:

- Automated monitoring systems are expensive to buy and maintain (need to be certain they are operational at time of event).
- Require confidence in the rigour and accuracy of citizen science programmes.
- Requires long term monitoring to define trends.
- Training programmes require engagement and buy-in from community members and groups.

Examples:

- Maramataka Climate Change Monitoring Project.
- CoastSnap Citizen Science.
- Project Baseline Wellington.
- Greater Wellington Environmental Data Dashboard.



wellington.govt.nz

Absolutely Positively
Wellington City Council
Me Heke Ki Pōneke