# Protect

## Ground reinforcements

**Groundwater**
- ✗ Rising groundwater

**Coastal**
- ✗ Erosion
- ✗ Flooding
- ✗ Tsunami

**Rainfall**
- ✗ Flooding

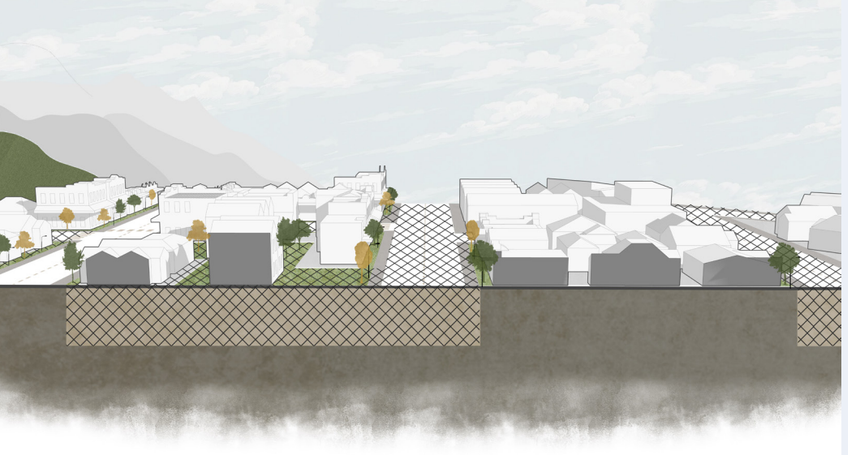
**Seismic**
- ✓ Earthquake
- ✓ Liquefaction
- ✗ Landslides

## Description

Ground reinforcement is a preventative method to stabilise soils and reduce liquefaction potential. Liquefaction is a loss of ground rigidity due to earthquake-induced water pressure. Ground reinforcement methods can be effective in reducing liquefaction potential by improving soil density and/or cohesion, thereby reducing water pressure (and lowering groundwater with some ground reinforcement options) and soil instability during seismic events.

Methods include densification of the crust or deeper liquifiable soils, crust strengthening, reinforcement, containment by ground reinforcement or curtain walls, and drainage improvements using stone columns or earthquake drums.

Ground reinforcement is one of a number of geotechnical responses to seismic risks, which include slope stabilization and the use of mesh fencing to reduce rockfall risk. These additional responses are not considered in this fact sheet due to the flat nature of the majority of South Dunedin.



### Interdependencies

To reinforce land, removal and redevelopment may be required. The reinforced land would require new connections to services (e.g. roads, water, power).

## Characteristics

### Pros

- **Maintained sense of place / identity:** By implementing ground improvements, long term benefits can be achieved in terms of reducing the risk of liquefaction and landslides and raising the ground level above future flood levels, thereby enhancing the overall sense of place.
- **Generational, flexible solutions:** Can provide sustained protection against seismic movements for generations. Can be retrofitted for future modifications and expansion.

### Cons

- **Cost:** The costs associated with ground reinforcement will be highly dependent on the outcomes from more detailed studies and the scale and complexity of the reinforcement work. Costs are likely to be very high, although these should be compared to the costs of doing nothing.
- **Technical feasibility and efficacy:** The feasibility of ground improvements at the scale needed to mitigate the liquefaction hazard risk needs to be assessed. Evaluation of efficacy of ground improvements to reduce risk would require a detailed understanding of soil behaviour under seismic conditions. Comprehensive geotechnical investigations are required, which may require further information and possible ground investigation to support this assessment.
- **Emissions, pollution and materials reuse:** Due to the material used, especially concrete, this approach increases carbon emissions. It also could affect natural landscape and water quality.
- **Time:** The process from the planning stage to the construction stage is very time-consuming and requires different skills and disciplines. Ground improvement measures require detailed ground investigation prior to developing an appropriate ground reinforcement design.
- **Social co-benefits:** Many ground reinforcement techniques (but not all) would require temporary relocation of residents and potential house/building removal, as well as construction disruptions across the area.

### Neutral

- **Health of and connection to the natural environment:** Ground reinforcement measures can control erosion and protect against loss of topsoil, preserving fertile land. However, some ground reinforcement techniques may involve disruptive construction activities or alteration of natural landforms which can result in habitat disruption and ecosystem modification.

## Strategic Considerations

In South Dunedin, implementing ground reinforcement measures could be logistically and technically challenging due to the area's low-lying and flat terrain. Investigation into soil composition and groundwater levels would be required. Ground reinforcement techniques could mitigate the liquefaction potential in South Dunedin and improve resilience to seismic events, providing greater community safety in place. The role of ground reinforcement is to reduce, not eliminate ground deformation, therefore ground mitigation measures are recommended to be included as part of an integrated liquefaction resilience solution. For example, ground reinforcement could be combined with vertical infrastructure such as deep foundations to further stabilise buildings. The efficacy of specific methods will depend on the local soil and groundwater conditions and the nature of the seismic activity. Some (but not all) ground reinforcement techniques would require temporary relocation of residents and potential house/building removal which would have social implications.

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| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | Ground reinforcements increase the safety and resilience of the buildings and the surrounding area against liquefaction, earthquakes and landslides. Ground reinforcements may also create opportunities for increased green spaces within urban areas, providing recreational areas for residents and enhancing overall urban aesthetics |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | Certain ground reinforcement techniques, such as the construction of retaining walls and deep foundations, can contribute to increased carbon emissions due to the use of concrete. In addition, these practices have the potential to disrupt biodiversity if they involve significant alterations to the natural landscape. Furthermore, ground reinforcement can have implications for water quality as sediments generated during construction may contain pollutants like suspended solids, heavy metals, and chemicals, posing risks to aquatic organisms and ecosystem stability. To assess the specific environmental impacts of ground reinforcement projects, it is recommended to conduct thorough environmental assessments tailored to the project site. Some ground reinforcement techniques may cause habitat destruction. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | Engaging the local community in voluntary initiatives to enhance building structures and foundations can be a promising approach. By providing stability to critical infrastructure, ground reinforcement measures support community activities. This contributes to serving community connections, which are essential elements of maintaining a sense of place and identity. However, voluntary initiatives may increase the risk of inequity as those with the means to adapt will, and those without the means will be forced to stay in vulnerable homes. |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | Ground reinforcement efforts can be initiated in critical areas, particularly where the presence of essential buildings or reliable site access is paramount. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | Even though there may be time and cost involved, implementing ground enforcement measures has important long-term advantages. Measures to strengthen buildings and infrastructure, makes them more resilient and gives people a sense of control over their surroundings. This increased safety helps improve how people feel and allows them to plan for a safer future. |

SOUTH DUNEDIN FUTURE

# Protect

## Groundwater lowering / drainage / dewatering wells

**Groundwater**
- ✓ Rising groundwater

**Coastal**
- ✗ Erosion
- ✓ Flooding
- ✗ Tsunami

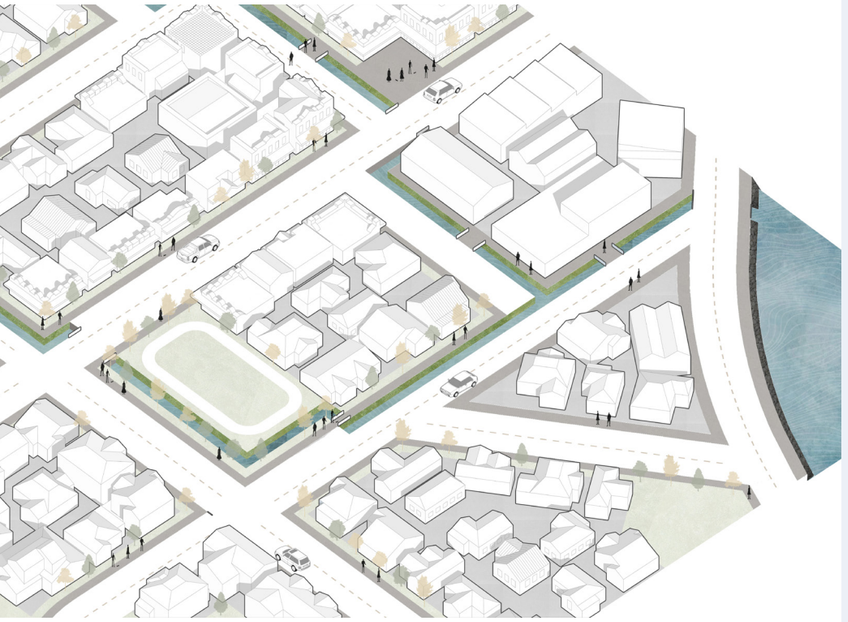
**Rainfall**
- ✓ Flooding

**Seismic**
- ✗ Earthquake
- ✓ Liquefaction
- ✗ Landslides

## Description

The presence of shallow groundwater beneath South Dunedin exposes the area to the threat of groundwater flooding. Groundwater can contribute to surface flooding and a large part of existing underground infrastructure is already under the water table, posing significant risk to old deteriorating systems. When the sea level rises, groundwater rises and flooding risk increases. This exposes underground structures and networks, building foundations and low-elevation roads to wetter conditions. Options to lower the groundwater could include drainage and dewatering wells.

The extent of the groundwater lowering is specific to soil type, groundwater conditions, geology and is limited to above ground surroundings.



### Interdependencies

Lowering groundwater would increase the capacity of the ground to absorb water; however, additional measures to reduce flood risk would be required. Renewal of stormwater and wastewater pipes in parallel should be considered if significant works are proposed.

## Characteristics

### Pros

- **Maintained sense of place / identity:** Reduces short term risks and does not change the landscape dramatically so not likely to be any aesthetic changes.
- **Health and connection to the natural environment:** Groundwater lowering can contribute to the well-being of the community by reducing health risks associated with groundwater flooding and promoting sustainable water management practices, which benefit the natural environment.

### Cons

- **Emissions, materials and pollution:** Carbon emissions generated due to the source of energy used for groundwater lowering and drainage activities. The energy (which could be generated by micro solar on pump stations) required for pumping and the potential for contaminant discharges from groundwater may result in some emissions and pollution. Less carbon intensive materials can be chosen and there is scope for renewals of wastewater or stormwater networks simultaneously to reduce the impacts of construction.
- **Generational, flexible solution:** Can be used on a small scale but not very feasible as a long-term generational solution.
- **Time:** Can be introduced when ground levels begin to rise as a result of rising sea level and is recommended as a medium-term solution. However, it is unlikely to be suitable in the long-term due to saltwater intrusion into the groundwater network.
- **Cost:** Implementing groundwater lowering will be costly, likely requiring changes in land use (at least temporarily) for either below ground drainage or for canals. There will also be an ongoing investment cost due to the level of monitoring and increasing levels of pumping required.
- **Technical feasibility and efficacy:** A feasible approach in the short term however subsurface networks and underground infrastructure will be exposed to rising groundwater over time. Very dependent on soil conditions and site specific and may result in increased ground subsidence over time due to frequent dewatering. Overall difficult to implement due to the large volumes of water and spatial area involved. Will require resource consent authorisation.
- **Social co-benefits:** The physical disruption caused by construction and ongoing pumping may temporarily impact the local environment. There is also a risk of ground subsidence.

### Neutral

- **Health of and connection to the natural environment:** Reduces the likelihood of flooding damaging the natural environment. Unlikely to improve the health or people's connection to the natural environment. Can also lead to the depletion of groundwater levels which may impact the availability of water for ecosystems.

## Strategic Considerations

Lowering the groundwater reduces the risk of pressures on underground structures, allows more infiltration of water into the sub surface to attenuate and treat rainfall as the soil is saturated post events for smaller periods of time. This may be a viable adaptation approach in the short to medium term; however, as sea levels rise, the ability to manage groundwater to an acceptable standard affordably may diminish.

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| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | This approach can manage water related risks and prevent damage to infrastructure and property, improving the urban environment and enhancing the overall livability of an area. Preventing excess moisture in the soil and minimizing standing water can support healthier living conditions by reducing the likelihood of mould and vector-borne water diseases. |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | Groundwater lowering, drainage and dewatering wells will help to prevent damage to biodiversity from flooding. It can also be used protect cultural heritage sites. Lowering the groundwater may have unintended consequences on ecosystems and water resources. Groundwater lowering and dewatering of wells can lead to the depletion of groundwater levels or alteration to hydrological patterns which may impact the availability of water for ecosystems and agriculture. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | There are limited opportunities for the community to be part of the adaptation process or take ownership. However, it is an equitable solution that is unlikely to further exacerbate existing inequalities as the benefits will be accessible by most. |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | In the short-term, groundwater lowering, drainage and dewatering wells can reduce groundwater flooding hazards, surface water flooding, and groundwater infiltration. However, this is only a short-term solution and is not likely to increase economic resilience in the long term. It is a costly solution that will require multiple upgrades as climate change hazards exacerbate. It can be expensive to install and operate. This can be a burden for businesses and communities and reduce social cohesion. Implementation of these options may result in the displacement of people and local businesses in the short term disrupting community wellbeing. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | This approach creates a safer environment in the short term as it reduces the risk of flooding, thereby preventing damage to infrastructure and properties. However, it is unlikely to promote safety in the long term. |

# Protect

## Land grading

**Groundwater**
- ✓ Rising groundwater

**Coastal**
- ✗ Erosion
- ✓ Flooding
- ✓ Tsunami

**Rainfall**
- ✓ Flooding

**Seismic**
- ✗ Earthquake
- ✗ Liquefaction
- ✗ Landslides

## Description

Land grading (also known as land elevation) is a flood risk management strategy that involves physically raising the ground level above the floodplain (existing and future). It is a measure that reduces the exposure of all activities located on the raised land because the floodplain extents have changed but requires consideration of flood risk management approaches alongside raising.

Much of South Dunedin's low-lying land was reclaimed from coastal marshes and intertidal deposits following European settlement in the late 1800s, levelled with a thin (~1.0 m) veneer of fill and developed into a residential area. Therefore, historically South Dunedin has implemented a "land elevation" technique which has served the area for ~150 years.

### Interdependencies

The area of land elevation required to elevate the desired number of people, places, and assets is strongly influenced by land use planning policy particularly regarding intensification rules and building height restrictions. The elevated land would require resilient connections to infrastructure services (e.g. roads, water, power). The elevation of access routes (e.g. streets) can be a limiting factor if access to raised land is frequently restricted This also requires cut and fill considerations to avoid displacing flooding and could be used in combination with other measures to reduce flooding.

SOUTH DUNEDIN FUTURE



## Characteristics

### Pros

- **Social co-benefits:** Raising land levels above the floodplain removes people, places and assets from flood risk (to the level of service agreed, for example 1% likelihood event in 2110 using a high emission scenario in accordance with the coastal hazards guidance). It is a long-term resilient approach which increases safety and contributes to community confidence and mental wellbeing.

### Cons

- **Cost:** Likely to be highly costly to implement due to large scale construction, building removal and replacement and earthworks.
- **Technical feasibility and efficacy:** High complexity and may not be feasible (cost, practicality, fill material). Considerations will need to be worked through such as what areas to be raised, where fill will be sourced from, how developed areas will be raised and what the interim impacts are (i.e. staged land raising). Given that land elevation will require "filling in a floodplain" there will likely be negative flood impacts elsewhere and if these cannot be managed resource consent approval will be difficult. Land elevation cannot be considered in isolation, which could present opportunities to utilise "cut" earthwork volumes from one approach (e.g. dedicated water storage, or floodable infrastructure) to raise land elsewhere. This is only an option if the material is suitable for raising land, which would require testing. If suitable material cannot be sourced nearby, then importing fill material would significantly increase cost (and carbon cost). There is also the practical issue of implementing this approach with existing buildings in place or via a piece-meal approach as building turnover occurs.
- **Emissions, pollution and material re-use:** The process of land elevation may involve contaminated soil excavation and disposal, and will produce emissions from the work involved.
- **Health of and connection to the natural environment:** Raising land levels historically in South Dunedin "buried" the natural environment and removed connection. This could occur again if not managed.

### Neutral

- **Generational, flexible solution:** Land elevation will provide long term benefits but future generations may continue to be faced with issues. Land raising is not a flexible solution as it is difficult to reverse once implemented.
- **Maintained sense of place/identity:** This would likely require temporary relocation of residents and removal of buildings. Consulting with the community and utilizing interdisciplinary approaches play an important role. Raising the land can impact sense of place and identity. Could result in people feeling a sense of disconnect from their community.

## Strategic Considerations

Implementing a land elevation approach in South Dunedin at a meaningful scale is likely to be highly complex and require consideration of many factors including the unique geology and topography of the area, the high groundwater table, poorly consolidated sediments, seismic risk, contaminated land, impacts on the horizontal infrastructure (including all utilities), temporary relocation of residents, potential house/building removal and sourcing the necessary quantities of suitable fill material. Although complex, land elevation enacted with a long-term design perspective can significantly reduce the risks associated with flooding, groundwater and coastal inundation hazards for people, properties, business and infrastructure which can be moved to higher, flat land.

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| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | Elevating land requires careful design and planning considerations; otherwise, it could create an urban eyesore and disrupt biodiversity. |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | Land elevation can have various environmental impacts, depending on the method used. This includes alterations to natural overland and subsurface drainage patterns, soil erosion, and disruptions to vegetation and wildlife. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | The decision-making process for land elevation projects should involve active engagement with the affected communities. Ensuring participation and inclusion can help address concerns, build trust, and create positive social outcomes. However, if partial land elevation occurs there may be a perception of unfairness if some parts of the community are not raised. |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | Those people, places and assets which can be moved to higher land through a land elevation approach will be at significantly less risk from flooding and thereby there will also be increased economic resilience. However, the technical feasibility and cost of this approach needs to be more fully considered before understanding the scale and efficacy of this approach for South Dunedin. There is the added complexity that the multi-decadal staging of a land elevation programme would need to be carefully considered to ensure that the potential negative flood effects on others are well addressed and local businesses are not impacted by long term construction activities in the area.<br><br>Raising ground levels may increase the frequency of limited or no access to the lower elevation streets during events. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | Implementing significant changes like this in urban areas will increase safety for those whose land is elevated. However, areas not raised will be subject to increased flood risk. |

# Protect

## Conveyance improvements

**Groundwater**
- ✓ Rising groundwater

**Coastal**
- × Erosion
- × Flooding
- × Tsunami

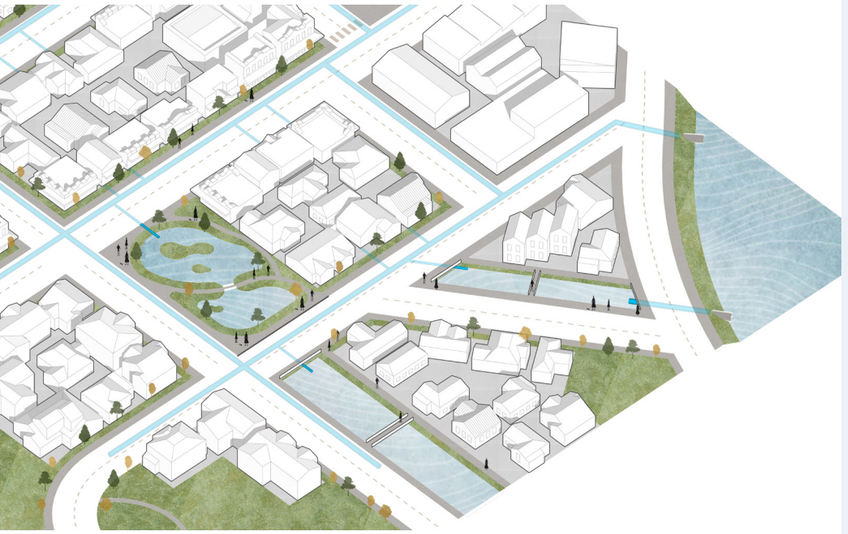
**Rainfall**
- ✓ Flooding

**Seismic**
- × Earthquake
- × Liquefaction
- × Landslides

## Description

Conveyance improvements involve the enhancement or modification of existing and new drainage systems. This might involve combinations of installing larger pumps and pipes to increase water flow, intercepting and diverting flows upstream, creating engineered channels or canals and/or enhancing stormwater conveyance capacity both overland and through piped networks.

The permanent and temporary use of flood storage, including planted infrastructure to support green-blue corridors is closely associated with conveyance improvement and therefore this approach should be considered alongside the “preparedness and response”, “dedicated water storage” and “floodable infrastructure” approaches.



### Interdependencies

Stormwater conveyance improvements should be considered alongside temporary and permanent flood storage solutions and alongside groundwater lowering and coastal protection approaches. Flood infrastructure should be included in preparedness and response planning.

## Characteristics

### Pros

- **Maintained sense of place/identity:** Improved stormwater conveyance may increase the sense of place if the amenity of the area is increased through more open space (open channels) and flood hazard reduced.
- **Health of and connection to the natural environment:** Incorporating sediment traps and biofiltration helps remove pollutants from stormwater runoff before reaching natural water. Green-blue corridors can create more green spaces and enhance the community’s connection to the environment.

### Cons

- **Cost:** Cost is subject to the size, scale and complexity of the conveyance improvements. It is likely that most solutions would require significant funds and land purchases, requiring approval through Council processes. The cost of implementing is likely high although it is currently unclear how this cost compares with the “do nothing” option. A maintenance programme to ensure the proper functioning will be required.
- **Emissions, pollution and material re-use:** In the short term, construction activities could increase energy consumption, lead to higher emissions, and be disruptive to existing ecosystems. The built elements will result in high carbon emissions. Green-blue corridors however have the potential to act as carbon sinks and absorb carbon dioxide.

### Neutral

- **Generational, flexible solution:** It is related to site-specific consideration. Useful for existing areas that are in danger of flooding. In the long term, planted conveyance can enhance wildlife habitat and improve water quality.
- **Social co-benefits:** An interception and diversion solution that benefits South Dunedin may require the cooperation and support from landowners that are not beneficiaries. However, in the long run, it brings resilience to the community. It can reduce the relocation of houses and businesses and will help economic growth.
- **Technical feasibility and efficacy:** Areas are protected by storing, displacing and conveying water into dedicated water storage areas in other locations or enabling faster discharge into the harbour. Evaluation of changing flood risk requires an understanding of many factors including the interactions between stormwater, groundwater and coastal inundation, and the current network performance and condition. Conveyance improvements such as fixing leaks and cross connections may also lead to increased groundwater levels resulting in maladaptation.

## Strategic Considerations

The low-lying, flat topography of South Dunedin presents challenges to stormwater conveyance due to the lack of gradient to convey flows by gravity to the coast, and the high groundwater levels limiting the potential for soakage/infiltration.

It is important that the stormwater conveyance system is considered alongside the wider “water” system since the stormwater, groundwater and sea level interact with each other. Given the difficulties previously outlined, this is why conveyance improvements should be considered alongside all other approaches. Some of the stormwater conveyance approaches may not result in reduced peak water levels during extreme storm events, but they may cause less frequent flooding, or shorter durations of flooding for less extreme events. The community’s acceptance of these outcomes needs to be assessed but it is expected that improved conveyance systems would contribute to public health outcomes and protect property and infrastructure.

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| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | Upgrades to conveyance systems can improve overall urban form by creating more open spaces. The addition of green-blue corridors can improve access to recreational and green spaces. Improved conveyance via pipes and pumps reduces risk to places and spaces but does not create space for wildlife. |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | Green-blue corridors can create a sense of environmental stewardship and uphold the concept of kaitiakitaka. These corridors serve as connections between Papatūanuku and Tangaroa, promoting the well-being of ecosystems and indigenous biodiversity. Other built conveyance improvements such as bigger pipes may require larger areas of disturbance and will not regenerate the environment. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | Effective conveyance systems reduce risk to properties and infrastructure from flood-related damages and will not exacerbate existing inequities |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | Effective conveyance systems protect properties and infrastructure from flood-related damages, preventing potential financial burdens for individuals and businesses. Reduced flood risks can also attract investment and promote economic growth in the area. This resilience builds confidence among residents in their ability to recover quickly from these events and adapt to future challenges. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | Upgrading conveyance systems can contribute to the overall safety and well-being of residents by reducing the risk of flooding and associated property damage. This enhances the quality of life, reduces stress, and provides peace of mind for individuals living in flood-prone areas. Proper conveyance systems prevent stagnant water accumulation, which can serve as breeding grounds for unwanted pests and the accumulation of pollutants, toxins and bacteria. By reducing standing water, upgrades can minimize the risk of waterborne diseases and vector-borne illnesses, benefiting public health. |

SOUTH DUNEDIN FUTURE

# Protect

## Remove wastewater network overflows and cross-connections

**Groundwater**
- ✗ Rising groundwater

**Rainfall**
- ✓ Flooding

**Coastal**
- ✗ Erosion
- ✗ Flooding
- ✗ Tsunami

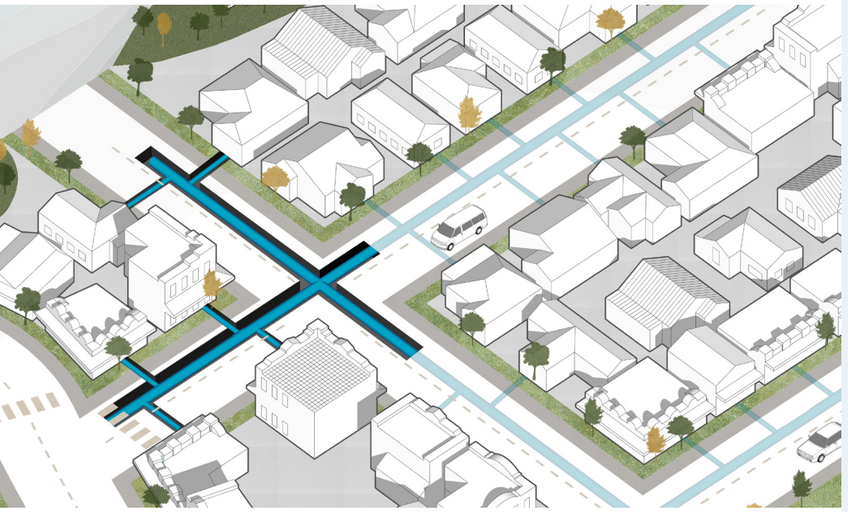
**Seismic**
- ✗ Earthquake
- ✗ Liquefaction
- ✗ Landslides

## Description

Removing wastewater network overflows would avoid wastewater spilling out from gully traps, manholes, or engineered/constructed overflow points when the network has reached full capacity protecting people from health risks associated with flooding. Stormwater "inflow and infiltration" into the wastewater network is a significant problem and a main cause for wastewater overflows.

Resolving wastewater network overflows and cross-connections can be achieved by measures such as fixing cracked pipes or manholes (that may have been caused by ground movement, deterioration of aged pipes or tree roots).

By improving/resolving wastewater network overflows and private cross-connections, this helps reduce the infiltration/overflow of stormwater into the wastewater network which then reduces the likelihood of wastewater overflows. This reduces the potential for bacterial (e.coli) contamination of stormwater which could result in an acute human health risk for the community as well as reducing contamination of receiving waterbodies and frequency/extent of surface water flooding.



### Interdependencies

There are limited interdependencies with this approach. While wastewater cross connections are being removed, additional below ground works could be actioned simultaneously to streamline construction. More capacity in the wastewater or stormwater networks may be required to offset resolving the leakage and cross connections.

SOUTH DUNEDIN FUTURE



## Characteristics

### Pros

- **Pollution:** This approach reduces the risk of releasing pollutants into natural water bodies, thereby improving water quality, preserving ecosystems, and reducing greenhouse gas emissions associated with treatment of wastewater (versus a larger volume diluted with water).
- **Health of and connection to the natural environment:** Resolving overflows and cross-connections improves the quality of water bodies used for recreation, drinking water sources, and aquatic habitats.
- **Maintained sense of place/identity:** Addressing overflows and cross-connections helps preserve the cultural and historical identity of communities by safeguarding natural water bodies, local heritage, and recreational spaces.

### Cons

- **Social co-benefits:** Local disruptions during construction may lead to temporary inconveniences or negative social impacts.
- **Generational, flexible solution:** The pace of implementation may not meet the immediate needs of a growing population or changing environmental conditions.
- **Cost:** Space for adding more storage through the wastewater (or stormwater) systems are limited by existing urban land uses. The costs to provide below ground storage are significant and the feasibility for delivery will be challenged by ground conditions, existing services, and high groundwater levels.
- **Emissions and material re-use:** Resolving network overflows and cross-connections through repair or replacement may require substantial material usage and result in carbon emissions.

### Neutral

- **Cost:** Improving/resolving wastewater overflows and illegal cross-connections would require capital budget approval but is generally within 'normal' capital spend, subject to the scale and pace of improvements. Thus, rehabilitation of the network would be a cost-effective solution compared to full replacement.
- **Generational, flexible solution:** Requires ongoing management and maintenance. However, can be flexible in terms of adapting to changing conditions. In many cases existing wastewater networks can be retrofitted with additional infrastructure.
- **Technical feasibility and efficacy:** Increased urbanisation associated with new greenfield housing and densification in existing areas will challenge the existing design parameters of the network. A potential consequence of reducing stormwater infiltration into wastewater is higher groundwater and reduced drainage as a result of reduced conveyance via the wastewater system.

## Strategic Considerations

This approach focuses on improving/resolving wastewater overflows and private cross-connections, which significantly reduces the acute human health risk due to the bacterial contamination from wastewater overflows and cross-connections. This can have significant cultural benefits as it can help to restore the mauri of sites of significance to mana whenua. A cleaner environment also improves broader social (beyond public health outcomes) and environmental outcomes by providing increased recreational and biodiversity opportunities.

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| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | Addressing overflows and cross-connections can reduce the risk of waterborne diseases and bacterial contamination, leading to improved public health outcomes for the community. Cleaner and safer water bodies can provide increased recreational opportunities, promoting physical and mental well-being for residents through activities like swimming, boating, and fishing |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | Resolving wastewater overflows and cross-connections enhances ecosystem resilience by reducing water pollution, aiding native flora and fauna. This restoration contributes to biodiversity preservation and improved water quality, benefiting both the environment and aquatic life, aligning with the principle of kaitiakitaka.<br>Many natural water bodies hold cultural significance for communities. Preserving these areas by resolving overflows and cross-connections could contribute to the cultural and spiritual well-being of the community, particularly for Māori/iwi groups. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | Communities affected by wastewater overflows often experience social and economic challenges due to degraded living conditions and potential health risks. By removing overflows, South Dunedin can experience improved quality of life, enhanced well-being and a safer environment for residents. |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | The improvement of infrastructure and environmental conditions can attract investment, create jobs, and boost the local economy, leading to greater economic well-being for the community.<br>By mitigating wastewater-related risks, such as flooding and contamination, the community becomes more resilient in the face of natural disasters and environmental challenges. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | Mitigating hazards related to wastewater issues increases community safety by reducing the risks associated with flooding, infrastructure failures, and water contamination. |

# Protect

## Dedicated water storage

**Groundwater**
- ✓ Rising groundwater

**Coastal**
- ✗ Erosion
- ✓ Flooding
- ✗ Tsunami

**Rainfall**
- ✓ Flooding

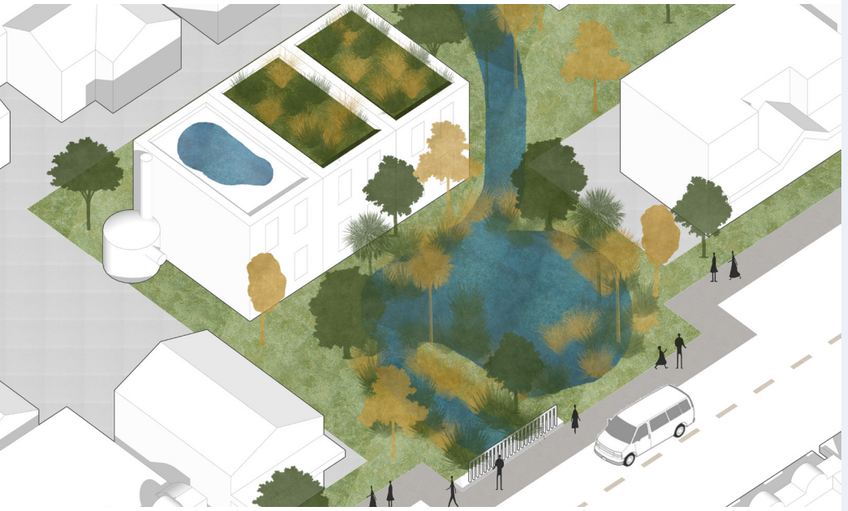
**Seismic**
- ✗ Earthquake
- ✗ Liquefaction
- ✗ Landslides

## Description

Dedicated water storage areas include detention basins, ponds and wetlands that can be located at the coast or inland. They feature a permanent allocation of land/space for water storage, which typically incorporates a permanent body of water and a "live" storage component which fills during storms and is slowly released once the storm has passed. Storage can be on surface or underground, although the high groundwater levels associated with South Dunedin preclude considering underground storage further.

Dedicated water storage can be incorporated into broader "Sponge City" or "Blue-Green corridor" spatial planning and stewardship concepts and/or restoration projects to enhance environmental and cultural outcomes (e.g. restoring historic wetlands).

The dedicated water storage approach helps prevent other areas from flooding by focusing water towards the basins, ponds and wetlands.



### Interdependencies

Best implemented alongside other approaches, but in particular "land elevation" (for the areas protected) and partial "retreat" to make space for new floodable infrastructure as well as inclusion in Preparedness and Response Plans. This approach is dependent on stormwater and wastewater renewal timing and is likely to require frequent pumping to discharge the excess water. It is also dependent on groundwater levels allowing for natural drainage after events or reduced volumes for storage due to infilling by groundwater.

SOUTH DUNEDIN FUTURE



## Characteristics

### Pros

- **Health of and connection to the natural environment:** Planted storage areas can provide habitats for aquatic and terrestrial species and promote biodiversity within urban areas. Provides more green space for the community.
- **Social co-benefits:** Planted storage areas can enhance the aesthetic value of an area, provide recreational spaces, and contribute to ecosystem services like carbon sequestration and temperature regulation. Greater access to the natural environment offers mental health and wellbeing benefits alongside recreational opportunities.
- **Emissions, materials and pollution:** Opportunity for carbon sequestration with the creation of planted storage. Detention basins can be planted and act as carbon sinks, absorbing carbon dioxide. Wetlands can also provide natural filtration improving air and water quality.
- **Generational, flexible solution:** Can provide long-term benefits by intercepting, temporarily storing and conveying water into dedicated storage areas in other locations. It has the potential for expansion or modification as climate conditions change over time. These solutions can also be integrated into the built environment.

### Cons

- **Social co-benefits:** Housing may need to be cleared for the creation of storage. The selection of suitable locations for implementing these measures may face challenges related to land ownership and community acceptance. This can also increase the competition for land outside of the basin, pond, wetland area for other purposes.
- **Technical feasibility and efficacy:** The slow natural drainage from the storage areas may require combinations with other approaches (e.g. pump stations) to be effective.

### Neutral

- **Maintained sense of place/identity:** Increased storage could change the sense of place in South Dunedin, but this accessibility of green spaces can be designed to enhance South Dunedin's identity and amenity. Also the restoration of the Kai Tuna wetland can help to reinstate community identity.
- **Material reuse:** Limited opportunity for these actions to provide for material reuse, but natural environment actions can require less materials overall.
- **Cost:** The cost is subject to the size, scale and complexity of the dedicated water storage feature. It is likely that most solutions would require significant funds and land purchases. The cost of implementing floodable infrastructure is likely high although it is currently unclear how this cost compares with the "do nothing" option. A maintenance programme will be required.

## Strategic Considerations

Dedicated water storage would be used to protect areas of South Dunedin from flooding by directing floodwaters (coastal or rainfall-induced) towards the "live" storage component of permanent water bodies. Utilising dedicated water storage features is likely to serve as an important component of a broad integrated flood management strategy. Implementing the approach requires careful design and planning to suit the local conditions (e.g. ground suitability and hydraulics) including how it may integrate with other urban planning and flood management aspects over time (e.g. land elevation raising or property level interventions).

There are enhanced opportunities to meet the outcomes desired for South Dunedin by incorporating significant planting into the dedicated water storage areas. Typically, temporary detention basins have fewer plants and plant diversity, whilst wetlands have the most. Choice of appropriate planting for the conditions is a key design criteria including how it may change overtime.

**Mana whenua can actively participate in the South Dunedin Future programme, including development and assessment of adaptation approaches. The guiding principles in Te Taki Haruru (autaketake, autakata, autūroa, and auora) will be incorporated into the work in consultation with Aukaha and mana whenua to give rise to partnership commitments in the SDF Programme Strategy.**

| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | Dedicated water storage areas like the creation of detention basins, wetlands and planted water storage may help to improve urban form and the overall livability of South Dunedin by improving access to green space and recreational areas. This can have mental health benefits to the community and improve wellbeing. |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | Dedicated water storage features can be used to support water re-use and other sustainability-focused initiatives. Where diverse planting is incorporated into the design there are opportunities to enrich urban biodiversity by providing a variety of habitats for aquatic and terrestrial species and establishing corridors for wildlife. They can also enhance water quality by filtering stormwater runoff, and enhance carbon sequestration embracing the concept of kaitiakitaka and acknowledging the interconnectedness of the taiao. Dedicated water storage areas can also serve as educational spaces to raise awareness about the interaction between biodiversity, natural hazards, infrastructure and urban planning. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | The loss of amenity and/or loss of service from the land that is repurposed for dedicated water storage has the potential to increase some inequities, create tension and reduce community cohesion. However this is dependent on the location, the existing land usage, the proposed changes to the built environment and the process for engagement with affected parties. |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | Floodwater would be directed towards dedicated water storage areas whilst leaving other areas less exposed. Currently there are large proportions of South Dunedin that are exposed to flooding and incorporating dedicated water storage areas presents an opportunity to reduce some of the risk to South Dunedin properties and businesses. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | Floodwater would be directed towards dedicated water storage areas whilst leaving other areas where people live and work being less exposed to the hazards. This tangible protection can provide a sense of security to residents and business owners. |

# Protect

## Floodable Infrastructure

**Groundwater**
- ✓ Rising groundwater

**Coastal**
- ✗ Erosion
- ✓ Flooding
- ✗ Tsunami

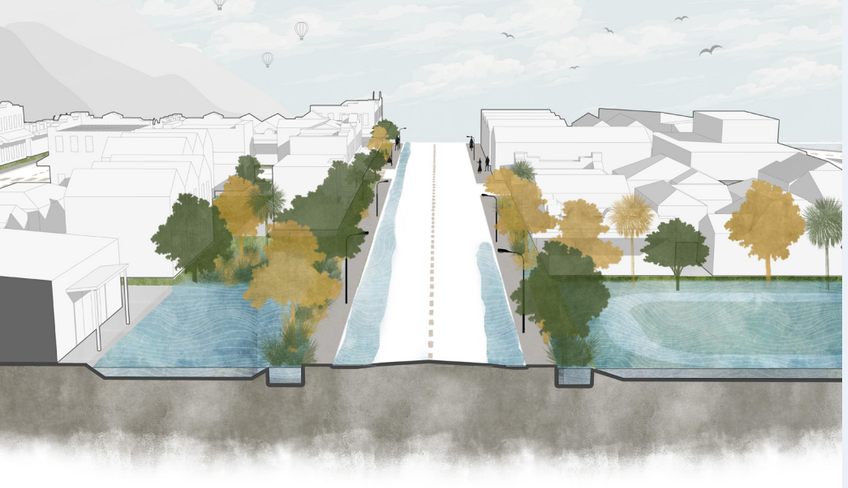
**Rainfall**
- ✓ Flooding

**Seismic**
- ✗ Earthquake
- ✗ Liquefaction
- ✗ Landslides

## Description

"Floodable infrastructure" refers to open spaces, green spaces (e.g., parks, reserves), carparks, and roads being transformed into intentional temporary flood storage zones or overland flow paths to protect other areas from flooding.

Given the flat nature of South Dunedin, the floodable infrastructure would need to be at a lower level than the surrounding area it is intended to protect (e.g. by raising surrounding area or lowering floodable area). However, where there is gradient available (e.g. to the east and west of South Dunedin), there may be options to store stormwater runoff further upstream as a way to protect areas further downstream in South Dunedin. While primarily designed to protect from coastal flooding and pluvial/fluvial flooding, it may also reduce groundwater levels if used in combination with an appropriate planting regime.



### Interdependencies

Floodable infrastructure is best implemented alongside other approaches that reduce pluvial flooding, in particular "land elevation" for the areas protected and partial "retreat" to make space for new floodable infrastructure. Understanding the likely frequency of future flooding for the floodable infrastructure will help determine the best land use when not flooded (e.g., frequent flooding of a car park may be less acceptable than flooding a park/ reserve area at the same frequency). Any floodable infrastructure approaches will need to be addressed in the Preparedness and Response plans to forewarn the community and clean up following flooding events may be required.

SOUTH DUNEDIN FUTURE



## Characteristics

### Pros

- **Technical feasibility and efficacy:** Intercepting, temporarily storing, and conveying water through planned floodable infrastructure areas protects other areas from flooding provided large enough storage can occur, including for potentially heavier rain events in the future. Large land areas therefore potentially required. There may be technical challenges regarding the feasibility of effectively infiltrating sufficient water into the subsoil due to high groundwater.
- **Emissions and materials:** While there are embodied emissions and materials required in creating floodable infrastructure, once operational, measures such as floodable green spaces can act as carbon sinks, absorbing carbon dioxide.
- **Health of and connection to the natural environment:** Green floodable infrastructure can be aesthetically pleasing and enhance the urban landscape and biodiversity.

### Cons

- **Social co-benefits:** Loss of amenity and/or service from the land or infrastructure that is temporarily flooded; variable impact dependent on land use (e.g. road, car park, reserve)
- **Cost:** The cost is subject to the size, scale and complexity of the floodable infrastructure solutions, including whether it makes use of existing spaces, or requires land purchases in addition to design, construction, and maintenance of new areas. Most solutions would likely require significant funds.
- **Pollution:** Floodwaters on roads can carry contaminants which can pose environmental and public health risks.

### Neutral

- **Generational, flexible solution:** Creating floodable infrastructure provides some flexibility and allows for future changes. Floodable infrastructure can be retrofitted and upgraded to meet future requirements dependant on maintenance and upgrades.
- **Maintained sense of place / identity:** Can be designed to integrate with the local context, preserving and celebrating South Dunedin's identity. However, may disrupt normal activities and alter the landscape, reducing sense of place for some.

## Strategic Considerations

Planted floodable infrastructure offers opportunities to meet the desired outcomes for South Dunedin. Considerations between planted- and hard- floodable infrastructure solutions as part of wider integrated urban planning needs to ensure sufficient space for non-"green" land uses (i.e. if all floodable land is green, then there will be increased competition for space outside of the floodplain for all other land uses). Other key considerations include transport, evacuation, business continuity and loss of amenity value and/or service of flood storage areas during flood events.

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| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | Floodable infrastructure provides many opportunities to support this outcome, although it will be dependent on which areas are used for temporary storage and what the land is used for when it is not flooded. If these areas are sculpted to be lower to have sufficient detention volume, then these parks and open spaces will be more susceptible to groundwater rise and semi-permanent dampness.<br><br>There are opportunities to align with the principle of waiora and prioritise ecological conservation and resilience. Well-designed green floodable infrastructure can contribute to the aesthetic appeal of an area, enhancing its sense of place. However it may reduce opportunities for some uses of the area to occur, albeit temporarily. |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | Floodable infrastructure, when implemented with a kaitiakitaka lens, goes beyond practical benefits. It can be used to support water re-use and other sustainability-focused initiatives. Planted floodable infrastructure can enrich urban biodiversity by providing a variety of habitats, creating space for plant species, and establishing corridors for wildlife. It can also enhance water quality by filtering stormwater and enhance carbon sequestration.<br><br>This revitalizes urban spaces in culturally meaningful ways. If incorporating planting, floodable infrastructure increases the connection to nature, promoting a renewed sense of belonging and re-energizing whakapapa with the land. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | Green floodable infrastructure solutions can provide opportunities for community working days to increase planting in neighbourhoods and private spaces. Native plants can be incorporated to transition towards a more natural environment. Some floodable infrastructure solutions may result in changes to the built environment, especially temporarily. Access to public spaces such as car parks and floodable greenspaces will be limited. This has the potential to increase inequities. |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | Floodwater would be directed towards floodable infrastructure areas whilst leaving other areas less exposed. This approach would be accompanied by community awareness allowing better preparedness and knowledge of those areas to stay away from (floodable areas). Recovery will be facilitated through post flood clean-up and a Response Plan. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | Floodwater would be directed towards floodable infrastructure areas whilst leaving other areas where people live and work being less exposed to the hazards. This tangible protection can provide a sense of security to residents and business owners. However, they may also present a safety hazard if frequently used public spaces are flooded without community awareness programmes and advice on areas to avoid. |

# Protect

## Increase permeability of ground surface

**Groundwater**
✕ Rising groundwater

**Rainfall**
✓ Flooding

**Coastal**
✕ Erosion
✕ Flooding
✕ Tsunami

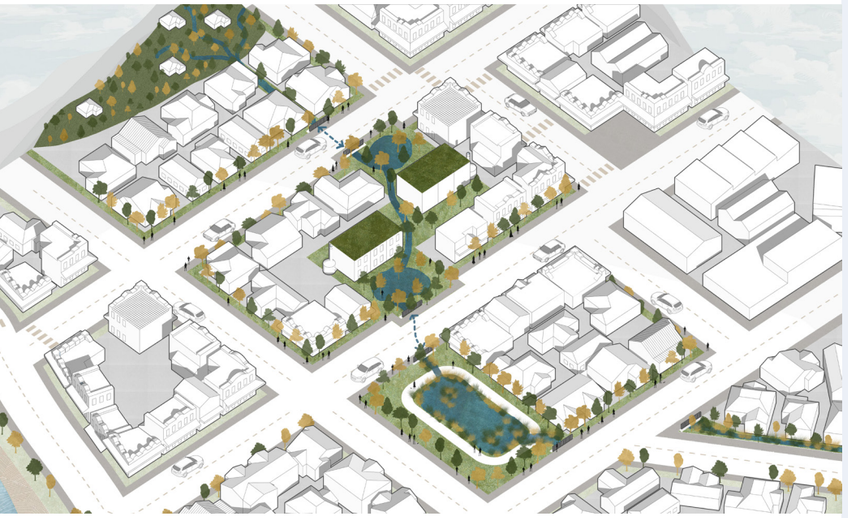
**Seismic**
✕ Earthquake
✕ Liquefaction
✕ Landslides

## Description

Increasing permeability of the ground surface improves the receiving environment's ability to absorb and/or manage excess rainwater, reducing the volume and rate of runoff that would otherwise go through to the stormwater network. Reducing peak volumetric flows of water is important in reducing flooding in urban areas. This could involve various strategies such as implementing green roofs, reducing impervious area of carparks or other surfaces, introducing rain gardens and/or bioswales, or planting more trees. These elements are often referred to as components of a 'sponge city' that soaks in rainwater/excess stormwater, filters it, and releases it slowly like a sponge, thereby reducing flooding and regulating water levels. Their efficacy can be limited by groundwater levels and the ability for the substrate to absorb additional water.

The introduction of natural elements can improve water quality, removing pollutants and sediment from water before it flows into surface water or aquifers, contributing to environmental outcomes.

The options of green roofs, bioswales and planting trees were suggested during public engagement events in October 2023 during the 'what matters most' phase.



### Interdependencies

Increased permeability should be considered alongside temporary and permanent flood storage solutions, conveyance, groundwater lowering and coastal protection options. Flood infrastructure should be included in preparedness and response planning.

SOUTH DUNEDIN FUTURE

South Dunedin Future - Long List of Generic Adaptation Approaches, Dec 2023

## Characteristics

### Pros

- **Health and connection to the natural environment:** Increasing permeability enhances local biodiversity, providing greater habitats for an array of plants, animals and microorganisms.
- **Social co-benefits:** Greater access to the natural environment offers mental health and wellbeing benefits alongside recreational opportunities. Green spaces, particularly more trees, also help with temperature regulation, noise reduction and providing shade for residents. Increased permeability in turn can help with amenity and desirability of the area.
- **Emissions, materials and pollution:** While there are emissions associated with the act of increasing permeability, once operational, rain gardens, trees and bioswales act as carbon sinks, absorbing carbon dioxide. They also provide natural filtration improving air and water quality.

### Cons

- **Technical feasibility and efficacy over time:** While actions can begin to be implemented in the short term, planting trees, and similar actions, can take a long time to become established, meaning their full benefit can take some time to be realised. They are only considered suitable for the short-medium term. Longer term implementation will begin to become unviable with higher groundwater levels associated with an increasing sea level reducing the absorptive capacity of soil.
- **Cost:** The initial cost for public infrastructure would require council capital budget approval but is generally within normal council spending. There would be higher ongoing-maintenance costs over its lifetime. Increasing permeability of private assets would likely be a cost borne by the owner.
- **Social co-benefits:** Carpark removal could need management to avoid accessibility impacts.

### Neutral

- **Generational, flexible solution:** Increasing permeability provides some flexibility and allows for future changes. Overall, generational efficacy is limited by rising groundwater and soil saturation levels. Ongoing maintenance is needed for the actions to remain at their optimal efficacy.
- **Material reuse:** Limited opportunity for these actions to provide for material reuse, but natural environment actions can require less materials overall.
- **Maintained sense of place/identity:** Increased green space could enhance sense of place through greater attachment to the environment but conversely the changing character of the area may adversely impact peoples existing sense of place.

## Strategic Considerations

This approach reduces risk through water management and enhanced drainage to promote soil and ecological health. As a result there are benefits for risk reduction and also biodiversity enhancement, resource stewardship and pollution management. The approach supports broader social, environmental, and cultural outcomes. In particular, the use of plants can have an added co-benefit of climate mitigation (greenhouse gas emissions sequestration) and therefore can contribute to wider climate action aspirations for Dunedin city. Utilising this approach alone would still result in flooding in extreme events, but it can be employed to enhance and complement other available approaches. Although yet to be explored with mana whenua, adaptation approaches that increase permeability and place the environment at the centre generally align more closely with a Te Ao Māori worldview.

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| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | Increasing permeability places the environment (Te Taiao) at the centre of the response, benefiting from the drainage capacity of plants and soil. These approaches can positively impact the wellbeing of the community through enhanced biodiversity including wildlife habitat and reduced pollution. They can also assist in achieving a vibrant and livable community given the enhanced connection and access to the natural environment and co-benefits of improved water quality and air quality. |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | Increasing permeability through rain gardens, green roofs and bioswales will directly contribute to environmental restoration. Planting of swales (bioswales) will have the added benefit of environmental enhancement through improved water quality and less pollution (air) and more green space. These practices honour the interconnectedness between humans and nature as well as our responsibility to enhance the mauri of the environment. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | An increase in permeability may result in changes to the built environment, such as decreasing the number of carparks or shifts to permeable pavements. These changes may present challenges for mobility potentially increasing inequities if not managed. |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | Local businesses could be involved in the initial implementation of additional green spaces and their ongoing maintenance. Increasing permeability will have limited impact on climate-resilient ventures/businesses in the long term. However enhanced amenity may attract more visitors to the area, potentially improving local economic opportunities. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | Increasing permeability can improve natural drainage, making space for water while maintaining space for people and increasing access to natural resources.<br>However, as the groundwater rises, there is less space below ground for rainfall to be absorbed naturally and, regardless of efforts to increase permeability, the effective permeability may be reduced as the soil becomes saturated. This limits the extent to which increased permeability can contribute to a safe and resilient community. |

# Protect

## Coastal protection

**Groundwater**
- ✗ Rising groundwater

**Rainfall**
- ✗ Flooding

**Coastal**
- ✓ Erosion
- ✓ Flooding
- ✓ Tsunami

**Seismic**
- ✗ Earthquake
- ✗ Liquefaction
- ✗ Landslides

### Description

Coastal protection comprises various tactics aimed at safeguarding coastal areas and can include 'hard' engineering options and 'soft engineering' options which each have their own strengths and drawbacks. For example, tsunami walls would need to be higher than sea walls to provide protection from coastal flooding (estimated 1-2m higher).

Hard options for coastal protection include sea walls, revetments, berms, dykes, tidal barriers, groynes, breakwaters and flap gates on stormwater networks. Some of these (seawalls, berms, dykes, tidal barriers and flap gates) can provide both erosion and flood protection while others (revetments, groynes and breakwaters) primarily provide erosion protection. Shoreline armouring (revetments, seawalls) to manage erosion may result in beach lowering in front of the hard structure while groynes and breakwaters interrupt the nearshore waves and currents to maintain sand on the beach. All types of shoreline armouring can result in end effects where the area downdrift of the structure erodes due to increased energy. Coastal structures would require other measures to protect against rain induced flood hazards and may exacerbate other flooding. This would require an understanding of the design life and residual risk of an over-design event or failure.

Engineering methods to reduce flooding are designed to create an impermeable barrier that keeps the sea from inundating land during a design event that would consider sea level rise, tide levels, storm surge and local wave effects. Soft engineering options like salt marsh, coastal wetlands, sand placement and dune restoration can be established at the coastal edge to reduce wave energy and surge effects and therefore erosion. However, such ecological methods do not act as barriers and are therefore unlikely to prevent inundation from sea level rise and astronomic tides.

**Interdependencies**

Should be used in combination with land elevation, drainage and conveyancing improvements.

SOUTH DUNEDIN FUTURE

South Dunedin Future - Long List of Generic Adaptation Approaches, Dec 2023

### Characteristics

**Pros**

- **Emissions, pollution and material re-use:** Structural components will have high embodied carbon but are expected to have low operational emissions. However, they involve use of materials. Soft engineering solutions have the potential to provide sequestration (e.g., salt marshes) or use recycled materials to reduce embodied carbon requirements.

**Cons**

- **Generational, flexible solution:** Structural solutions may result in lock-in of protection options and reduced capacity for future adaptation, particularly where changing environmental conditions result in engineered solutions no longer functioning effectively (e.g., overtopping of sea walls due to rising sea levels). However, they can be designed to allow for retrofitting over time to shift with community expectations.
- **Technical feasibility and efficacy:** Reduces risk to people, places and assets within the protected area, but can cause negative effects on drainage from rainfall-induced flooding and groundwater and can also increase the residual risk from overtopping, undermining or breaches if development behind the line of protection is intensified. There are many wider benefits to implement soft engineering solutions along the coast, particularly in regard to preventing erosion from wave effects. Soft engineering solutions do not mitigate the projected flooding or tsunami hazards. Permeable coastal protection measures are also ineffective from protecting South Dunedin from groundwater elevation due to sea level rise.
- **Cost:** The cost is subject to the size, scale and complexity of the coastal protection. However, the cost of implementing flood protection will be high.

**Neutral**

- **Natural environment:** Minimal direct environmental impact but may influence coastal processes (i.e., sediment transport) depending on solution selected.
- **Social co-benefits:** Positive and negative changes in area amenity and connection are possible dependent on protection measure (e.g., nature-based vs. structural). Physical barrier options may limit community access (e.g., sea access for recreation).
- **Maintained sense of place / identity:** Physical changes to space and ability to access areas surrounding protection measures, however soft engineering solutions may lead to an increased sense of place and a new identity through enhanced ecological outcomes.

### Strategic Considerations

Coastal protection for erosion or inundation caused by sea level rise, astronomic tides and storm events from the Otago Harbour could be achieved through hard or soft engineering measures such as sea walls or dykes and coastal wetlands. Tsunami risk reduction would require large seawall structures and will therefore be a visual barrier, reducing connectivity with the coast. Protection against erosion could include groynes and breakwaters and natural barriers such as dune restoration but the design will need to incorporate provision for rising sea levels to provide long term efficacy. Physical protection can provide a sense of security and safety for the community but may result in maladaptation if that sense of safety encourages further development behind the protection. The technical design and efficacy of coastal protection is linked to the height of the barrier and the ground conditions with residual risk associated with "over-design" events. Coastal protection can provide immediate and strong resistance, but their efficacy varies from place to place and their long-term sustainability and impacts on other coastal processes requires further investigation. Coastal flood protection only protects from the water coming in from the harbour and the Pacific South coast but does not address the pluvial/fluvial and groundwater flooding issues unless combined with other strategies. The use of hard protection options is discouraged in favour of soft engineering and longer-term strategic management in the New Zealand Coastal Policy Statement 2010. However, seawalls are presently in use along the harbourside managing some flood and erosion risk so are a familiar option to the community. Soft engineering options work with the environment and may be more aligned with a Te Ao Māori worldview.

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| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | Coastal protection works by altering nature processes and as a result can dramatically change the environment including places enjoyed by people and natural habitat.<br>Soft engineering options could have community wellbeing co-benefits through the creation of high amenity value spaces for the enjoyment of South Dunedin residents. |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | Implementation of nature-based protection approaches has the potential to result in enhanced environmental outcomes, such as increases in habitat for coastal nesting birds within and behind protective structures. Such initiatives can help to maintain the mauri of the taiao.<br>Physical hard structures will impact coastal processes such as wave action and sediment transport and may result in landform changes, impact cultural sites and adversely impact the connection between urban areas and the water. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | Coastal protection systems can be funded a range of different ways, including entire communities pay due to the communal use of the coast to beneficiaries pay. The cost of coastal protection may be borne by parts of the community that cannot afford a rates increase and do not directly benefit, potentially increasing existing inequities. |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | Coastal protection for both the Otago Harbourside and the South Pacific Coast will reduce the risk of damaging coastal inundation events for local people and businesses, limiting the cost of repair and replacement of assets.<br>Coastal protection approaches will not address pluvial flooding and may exacerbate flooding issues for communities and businesses. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | Coastal flood protection on the Otago Harbourside will reduce the risk of damaging coastal flood events for local people and businesses, helping people living and working in this area to feel safe and cared for. However, coastal protection will not improve safety from pluvial flooding and this will need to be considered in the design of coastal protection so that risks are not increased over time. |

# Accommodate

## Behavioural / societal changes

**Groundwater**
- ✓ Rising groundwater

**Coastal**
- ✓ Erosion
- ✓ Flooding
- ✓ Tsunami

**Rainfall**
- ✓ Flooding

**Seismic**
- ✓ Earthquake
- ✓ Liquefaction
- ✓ Landslides

## Description

Resilience can be understood as the ability to prepare, respond, cope, and recover from natural hazard events, learning from past experiences and adapting accordingly. In the context of societal and behavioral changes, resilience strategies aim to reduce the impacts of hazards by emphasizing prevention and preparedness. Potential approaches to increase community resilience and understanding of climate hazards include:

· Mental health support

· Climate hazard safety education and awareness

· Financial incentives / disincentives (e.g. rates rebates to encourage resilient modifications or increases in insurance cost [not Council driven] reflective of increased risk)


### Interdependencies

This approach can be used alongside all other approaches to increase social resilience of communities.

## Characteristics

### Pros

- **Time:** Behavioural/societal changes to increase community resilience can begin to be implemented within the current timeframe. These approaches are likely to be suitable in the short to medium term. The increasing risk of climate hazards in the longer term may make behavioural changes insufficient as an adaptation measure.
- **Cost:** Can be executed within Council operational budgets.
- **Social co-benefits:** Mental health support and flood safety education awareness can improve community wellbeing and may better equip people to make informed choices and deal with events when they occur.
- **Emissions, materials and pollution:** Focussed primarily on addressing the psychological and emotional impacts of flooding. Unlikely to generate substantial emissions.
- **Health of and connection to the natural environment:** Flood safety education and awareness can help people understand the impacts of flooding on the natural environment. Educating communities on the importance of preserving local ecosystems can foster a sense of kaitiakitaka.
- **Technical feasibility and efficacy:** These are 'no regrets' approaches - meaning that there will be benefits no matter what future level of climate risk is present. However, their effectiveness is limited by the degree of uptake.

### Cons

- **Social co-benefits:** Behavioural/societal change may result in changes to insurance premiums and/or ability to insure which would likely have inequitable economic consequences. Affordability will be reduced and this may have flow on mental and physical impacts. Financial incentives/disincentives can also create economic inequities. Community tolerance for financial disincentives will vary and community members may get left behind. Such incentives can impact community cohesion and create tensions.
- **Maintained sense of place / identity:** There are no benefits to the acceptance of lower levels of service. This is likely to diminish people's sense of place and identity. Also likely to result in wellbeing and economic impacts.
- **Health of and connection to the natural environment:** Acceptance of lower levels of service may result in less of a connection to the natural environment as sense of place diminishes.

### Neutral

- **Generational, flexible solution:** Providing mental health support is a generational strategy as it addresses the long term emotional and psychological impacts of climate change.

## Strategic Considerations

Behavioural / societal change responds to the existing vulnerabilities of the South Dunedin community to enhance community and individual resilience, contributing to South Dunedin having healthy, safe and connected people. While not reducing climate hazards exposure, by assisting the community in preparing for future events and giving resources to expand capacity by providing guidance, this could support 'learning to live' with water and making specific interventions that help to reduce the impacts on health, discomfort, and trauma from natural hazards. In turn, individual or community actions as a result of this approach could indirectly contribute to climate, biodiversity and other broader outcomes.

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| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | If the community is better prepared mentally for climate hazards it can contribute to improving overall waiora. These initiatives can help create a sense of community well-being by fostering community cohesion and social support networks. |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | Flood safety education and awareness can indirectly contribute to a more sustainable environment by helping the community understand how climate change can affect local ecosystems, water quality and wildlife habitats. This includes collaborating with Māori and iwi to incorporate matauraka Māori into education programmes.<br>This approach does not directly enhance biodiversity or water quality. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | Mental health support and flood safety education and awareness for all is an equitable initiative that will improve resilience providing there are the resources available to reach all members of the community. However, if insurance companies significantly raise premiums it will disproportionately affect low-income earners.<br>Financial disincentives can also result in limited approaches for those who are constrained financially. |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | Behavioural and societal changes will enable people to develop adaptable resilient behaviours to manage the impact of hazards. It can result in the community being more mentally prepared. However, this approach does not reduce the physical risk to climate hazards. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | These approaches will not reduce the physical risk to climate hazards. Although greater awareness of flood hazards and potential risk to safety may better prepare communities, it will not be an effective long-term solution on its own in the face of increasing risks. |

# Accommodate

## Readiness and Response

**Groundwater**
✗ Rising groundwater

**Coastal**
✗ Erosion
✓ Flooding
✓ Tsunami

**Rainfall**
✓ Flooding

**Seismic**
✓ Earthquake
✓ Liquefaction
✓ Landslides

## Description

Readiness (also known as “preparedness”) measures typically refer to the operational systems, capabilities and educational activities that are put in place before an acute event. Response refers to actions taken during or immediately after an emergency event like flood or earthquake. Readiness and Response planning generally falls within the responsibilities of Civil Defence Emergency Management (CDEM) – e.g. outside of the traditional PARA adaptation framework – and these responsibilities extend across a range of organisations, including Lifeline Utility Providers and critical infrastructure entities.

Readiness and response work would typically involve consideration of risk assessment and planning, early warning systems, public education campaigns, emergency response plans, including deploying temporary flood barriers (e.g. sandbags) and providing support services prior, during and immediately after an event. These approaches are not mutually exclusive of each other and readiness and response planning are essential across all the Protect, Accommodate, Retreat, and Avoid (PARA) approaches to effectively reduce risk. Readiness and response provide critically important short term benefits during and immediately following an emergency event, increasing the resilience of communities.

### Interdependencies

Readiness and response are used in combination with other measures including long term adaptation (PARA) approaches to reduce risk (Reduction) and post-event Recovery (e.g. all 4R’s of emergency management are recommended). Many approaches are multi-agency, requiring collaboration and coordination.

SOUTH DUNEDIN FUTURE

South Dunedin Future - Long List of Generic Adaptation Approaches, Dec 2023

## Characteristics

### Pros

- **Technical feasibility and efficacy:** Readiness and response activities help minimise injury, loss of life, and property damage during an event/disaster whilst also supporting recovery after an event. Often these measures are dependent on the awareness and subsequent action of community members. Unlike many hard engineered measures, effectiveness is hard to measure pre-implementation, but success is driven by effective coordination and communication, along with appropriate, regular training and exercising of staff and communities.
- **Time and cost:** These measures may require additional funding from a range of sources including local, governmental, or public-private partnerships. It takes time to increase awareness within communities, to establish monitoring for decision making and to conduct assessments which underpin the readiness and response plans. While effective readiness and response planning takes time to develop and socialize, these are effective measures to enhance community resilience.
- **Emissions, pollution and material re-use:** This approach does not build anything (e.g. spend carbon).
- **Generational, flexible solution:** Readiness planning and emergency response can be adapted over time to changing conditions and human behaviours.

### Neutral

- **Social co-benefits:** Fostering a culture of readiness within the community through coordinated education initiatives, community outreach, and public awareness campaigns is important. These programmes can lead to a centralization of power, or to a focus on technological solutions at the expense of more holistic and community-based approaches.
- **Health and connection to the natural environment:** The natural environment is not enhanced or altered by readiness measures, but education of communities on hazards may result in increased connection and respect for the environment.
- **Maintained sense of place / identity:** These measures focus on reducing risk to life during an event allowing communities to remain in place, but place less emphasis on reducing risk to property. Following hazard events there may be impacts to sense of place if buildings are flooded and temporary displacement may be required.

## Strategic Considerations

Developing Readiness and Response measures is standard practice across New Zealand for differing hazards and wider emergency events. Successful readiness and response activities help create broader community resilience, minimising injury, loss of life, and property damage during an event/disaster. Although this approach doesn’t eliminate natural hazard risks, it can reduce the adverse effects on communities on an event-by-event scale. Feasibility of these approaches is less governed by geographic conditions, and more by the community, with human behaviours/decisions being key to successful outcomes. South Dunedin’s unique challenges and hazard characteristics will serve as critical factors with implementation requiring coordination and a shared vision of resilience that involves local governing bodies, emergency services, and community.

**Mana whenua can actively participate in the South Dunedin Future programme, including development and assessment of adaptation approaches. The guiding principles in Te Taki Haruru (autaketake, autakata, autūroa, and auora) will be incorporated into the work in consultation with Aukaha and mana whenua to give rise to partnership commitments in the SDF Programme Strategy.**

| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | These approaches will not result in improved urban form, but civil defence readiness can help to ensure South Dunedin has the capacity to withstand climate change hazards and reduce the potential damage caused. |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | The role of CDEM could be extended to activities such as promoting and advocating kaitiakitaka, mātauraka and government policies and programs that support climate change readiness and response. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | Effective “Readiness and Response” planning includes working with communities to develop and implement plans that are culturally appropriate and inclusive, supporting community-led initiatives, conducting equity assessments of policies and programs, targeting resources to communities that are most vulnerable to climate change impacts, and working with Māori/iwi to incorporate mātauranga Māori and cultural practices. |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | Readiness and response reduces risk to life and allows communities to prepare to cope with hazards; however, beyond having temporary measures ready (e.g. sand bags), there is limited reduction in risk to the built environment. Community resilience is strengthened through planning and readiness activities by developing a plan and promoting connections within communities and businesses to prepare for a response. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | Readiness and response programs help communities feel prepared for hazard events through support for early-warning programs, training for community members and emergency responders, supporting community-led initiatives building resilience and social cohesion, and improving communication and engagement with community. The level of impact will be dependent on the type and magnitude of investment and therefore may not protect communities’ well-being from long-term effects of natural disasters. |

# Accommodate

## Property level interventions

**Groundwater**
- ✓ Rising groundwater

**Coastal**
- ✓ Erosion
- ✓ Flooding
- ✓ Tsunami

**Rainfall**
- ✓ Flooding

**Seismic**
- ✓ Earthquake
- ✓ Liquefaction
- ✓ Landslides

## Description

Property level interventions refer to adjustments or modifications that are made directly to individual properties to enhance their resilience against flooding. These could include raising homes, waterproofing first floors, raintanks, flood barriers, or other individual property level interventions.

Property level interventions are generally divided into two types:

Resistance measures are designed to mitigate the impact of external factors, acting as protective barriers against potential threats, such as bunding or small flood gates preventing flood water from entering a house.

Resilience measures focus on strengthening a system's ability to endure shocks, recuperate, and adjust, underlining its responsiveness and adaptability. For example, floodable first floors.

Typically, property level interventions are applied to residential properties although they may be applicable to commercial and industrial building types.

### Interdependencies

Complements alternative adaptation approaches as a site-specific approach, requires preparedness plans, public awareness campaign, and may require regulatory changes or incentives to encourage uptake.

## Characteristics

### Pros

- **Social co-benefits:** Improves property level resilience. Likely to result in improved living conditions.
- **Maintained sense of place / identity:** Builds resilience and allows people to stay in their homes for longer. Maintained sense of place as the measures are unlikely to change the features of the wider area.
- **Time:** Relatively simple and quick to implement.

### Cons

- **Emissions and pollutions:** Likely to be associated with high emissions due to reconstructed buildings and infrastructure. Also potential contaminants from sites that are flooded.
- **Costs:** Cost of property level interventions are likely to be borne, at least partially, by property owners and therefore may increase existing inequities.
- **Technical feasibility and efficacy:** While feasible to adapt some buildings, older buildings in the South Dunedin area may require a complete rebuild given their age and condition and any historic buildings will require authorisation for any significant modification. The options will also require property owner consent.

### Neutral

- **Materials:** Opportunity for the use of recycled materials, especially for rainwater tanks.
- **Generational, flexible solution:** Waterproofing can enhance the durability of buildings, making them more resistant to flood damage and potentially extending their lifespan. Can also be applied to existing buildings, making it a flexible approach. Most property level interventions require ongoing maintenance and are not suitable to all types of buildings.
- **Health of and connection to the natural environment:** Rainwater tanks can raise awareness about the value of water as a natural resource. However, waterproofed buildings and floating buildings have limited opportunities to enhance the health of the natural environment unless they incorporate eco-friendly design features.

## Strategic Considerations

The property level interventions will improve the overall quality of the housing stock in South Dunedin and therefore have the potential to have wider strategic benefits than purely risk reduction. For example, the intervention measures may be complimented with other building resilience and improvement measures such as earthquake reinforcement and insulation to mitigate increasing temperatures and removal of mould, thereby creating healthier homes.

There may be opportunities for economies of scale in implementing particular property level interventions. However, the interventions may increase the value of the property and this could have implications for the Dunedin social housing policy of affordable housing.

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| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | Property level interventions can enhance community wellbeing by improving property level resilience and improving living conditions. However, there are limited opportunities for property level interventions to improve urban form. |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | Rainwater tanks can promote water conservation and sustainable use and raise awareness of the local water cycle, the importance of water conservation, and the value of natural water sources.<br>More structural property level interventions (e.g. raising houses) may provide little to no opportunity to restore and regenerate the natural environment but may renew urban spaces and cultural connections by increasing the resilience of the urban environment. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | Could further exacerbate existing inequities as some property level interventions may not be suitable for all residents, including those with mobility issues. As the cost for the approach likely borne by the owners there is a risk that rental costs go up. Some residents might not be able to afford property level interventions even with government support. |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | Resistance and resilience measures support risk reduction by increasing the buildings resilience to flooding. This helps to support more climate resilient businesses and homes, which helps create a more vibrant and livable community. Property level interventions do not have much impact on infrastructure or amenities. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | Whilst these approaches will reduce risk, a high residual risk remains (and will increase over time) and there is no reduction in risk outside of the properties (such as ground level assets and vehicles parked outdoors). This may provide an overly optimistic sense of security and may be perceived as delaying decisions for additional adaptation. |

# Retreat

## Reactive Retreat

**Groundwater**
- ✓ Rising groundwater

**Coastal**
- ✓ Erosion
- ✓ Flooding
- ✓ Tsunami

**Rainfall**
- ✓ Flooding

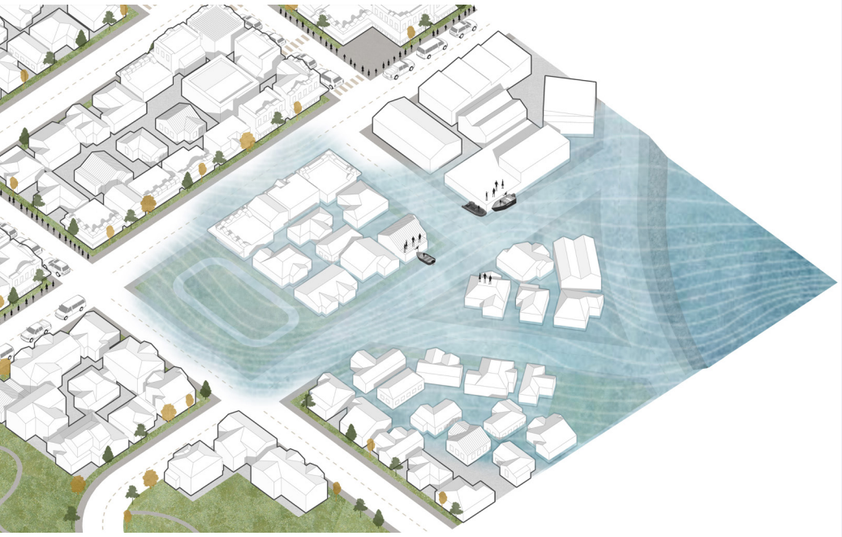
**Seismic**
- ✓ Earthquake
- ✓ Liquefaction
- ✓ Landslides

## Description

Reactive retreat is the withdrawal, relocation or abandonment of private or public assets in response to immediate threats or after damage has already occurred. It involves a more reactive approach where decisions are made in direct response to acute events like storms, flooding, tsunami, earthquakes or rapid erosion. Reactive retreat tends to be more abrupt and often significant damage to infrastructure has already occurred. It may involve emergency evacuations or the relocation of affected communities and infrastructure due to sudden changes in conditions. Reactive retreat can include:

· Post-disaster buyouts or post-insurance withdrawal buyouts

· Emergency evacuation



### Interdependencies

Retreat is an approach best implemented alongside other adaptation measures such as using vacated land for stormwater conveyance or storage opportunities.

SOUTH DUNEDIN FUTURE





## Characteristics

### Pros

· **Maintained sense of place/identity:** Allows people to stay in their homes until a significant damaging event occurs. .

### Cons

· **Maintained sense of place/identity:** Retreat will result in a loss of sense of connection to place, and reactive retreat usually happens without much warning post hazard event. Retreating from important cultural spaces (e.g., rohe moana, urupā) will have significant impacts on Māori communities and may result in a sense of displacement and loss of cultural identity.

· **Cost:** Costs are likely to be very high and it is likely the long-term costs will be higher than pro-active retreat due to the compressed timelines for the retreat and regeneration process. There is future uncertainty associated with government funding assistance in the event of emergencies and availability of insurance to cover costs.

· **Natural environment:** As reactive retreat typically occurs in a post-hazard event scenario, there would likely be environmental degradation from pollution occurring during the hazard event (that would be a naturalised area if retreat was pre-emptive). However, there is the opportunity to regenerate natural processes and habitats on vacant land post retreat.

· **Social co-benefits:** Reactive retreat measures will disproportionately impact vulnerable populations who lack the resources or means to effectively adapt or recover. Without pre-planning there may not be any acceptable alternative accommodation if a community is forced to move unexpectedly. Reactive retreat leaves little time for planning and implementing comprehensive adaptation strategies which limits the ability to implement an equitable adaptation response.

· **Emissions, pollution and material re-use:** Reactive retreat will likely have more waste than proactive retreat as materials from damaged properties are likely to be less suitable for re-use. There will be carbon requirements associated with upgrading or providing new infrastructure in other locations as well as for clean up and emergency response.

· **Generational, flexible solution:** The retreat from an at risk area post-hard can result in long term benefits that serve multiple generations but places the burden possibly on future generations that will experience the hazard event and live with the costs. It is not flexible given the associated cost and infrastructure associated with reversing any retreat decision, and the compressed timeline may mean that property owners have fewer options during the retreat process.

· **Technical feasibility and efficacy:** Emergency services will first evacuate and potentially rescue communities. If the damage is widespread, communities may lack the resources to have an effective emergency response, and this may hinder relocation efforts. The retreat process can be very complex and have significant challenges (economic, social, cultural) for all partners and stakeholders to ensure a just transition, and the process is more challenging post-hazard when people do not have basic needs met or are not in a comfortable living environment.

## Strategic Considerations

Retreat is usually a voluntary process, driven through incentives or risk-based pricing penalisation (e.g. insurance) although aspects of retreat can be mandated (e.g. Public Works). There is likely to be further legislative reform in coming years that will consider retreat implementation. Retreat is primarily a planning and community centered approach although its success is inextricably linked to where people and property move to (e.g. designating new development zones and developing new infrastructure), and what is done with the hazard effected land in a post-retreat scenario. A reactive retreat may result in less community participation as decisions will need to be made quickly. Implementing retreat strategies (including potentially plans for post-hazard retreat) in South Dunedin would require careful planning, a deep understanding of local social and economic factors, and meticulous logistical coordination to manage land use transition towards safe zones.

**Mana whenua can actively participate in the South Dunedin Future programme, including development and assessment of adaptation approaches. The guiding principles in Te Taki Haruru (autaketake, autakata, autūroa, and auora) will be incorporated into the work in consultation with Aukaha and mana whenua to give rise to partnership commitments in the SDF Programme Strategy.**

| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | Post-hazard reactive retreat is often in response to widespread property damage. This will have negative impacts on the urban form of South Dunedin as the retreat and regeneration process will take some time, particularly if property owners are waiting for insurance payouts. This may result in temporarily poor conditions for people and ecosystems until retreat is actioned and cleanup is complete. |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | Waiting to retreat until following a hazard event is likely to have negative short term impacts on the natural environment and urban spaces; however, retreat provides an opportunity to enhance environmental outcomes through enhanced biodiversity within these spaces. Embracing the concept of kaitiakitaka, retaining these areas as public green space (where practicable) will allow continued access for those with strong connections to the impacted areas and create additional environmental and societal co-benefits through effective planning and design processes. Retreat will potentially significantly impact on cultural connections and ties to the area but could enable culturally appropriate environmental restoration. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | The rapid, ad-hoc relocation of residents into existing communities could lead to the loss of social cohesion due to spatial separation, and this would be enhanced if it was a larger scale post-hazard retreat compared to a transition over time. There is also the potential for economic inequities to be magnified as those who cannot afford insurance will be impacted more significantly and will have greater difficulties in finding somewhere affordable to live or reestablish. The delayed retreat response leaves little time for planning and implementing comprehensive adaptation strategies which limits the ability to implement an equitable adaptation response. |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | Retreat of people, property and assets away from hazardous areas in a reactive way following an event will have significant impacts on communities and businesses and they may not have the means or plans in place to be able to recover. Once retreated the resilience of the community in the long term will be increased primarily because people and business are less disrupted (both socially and economically). The areas that people and businesses relocate to are beneficiaries of retreat, therefore South Dunedin's resilience is enhanced when relocations within the South Dunedin area are maximized. Other areas outside of South Dunedin may also benefit. However, in the short term between the hazard event and completion of relocation and regeneration, it is likely that communities and businesses will be significantly negatively impacted. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | Reactive retreat following a significantly damaging event will increase the risk to community safety and leaves people exposed to the natural hazard risk. Once relocated, the safety and security of individuals and families will be enhanced in the long term, reducing the risk of injury and loss of life from subsequent events. There will be considerable stress in the short term and often PTSD in the medium term. In the long term retreat from the area reduces the stress associated with living in hazardous areas although the social dynamics, psychological impacts and stress associated with reactive retreat are important considerations in both the short, medium and long term. |

# Retreat

## Managed Relocation

**Groundwater**
- ✓ Rising groundwater

**Coastal**
- ✓ Erosion
- ✓ Flooding
- ✓ Tsunami

**Rainfall**
- ✓ Flooding

**Seismic**
- ✓ Earthquake
- ✓ Liquefaction
- ✓ Landslides

## Description

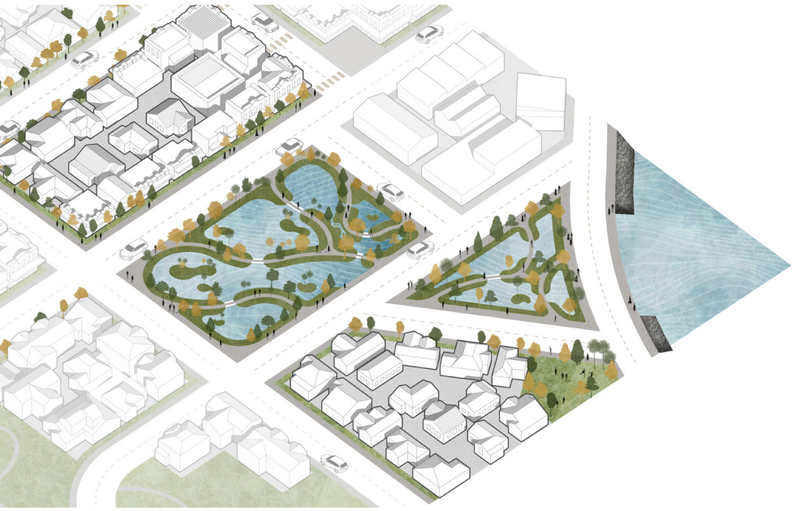
Managed relocation (proactive retreat) is a strategic decision to withdraw, relocate or abandon private or public assets (including land and buildings) before significant damage occurs. It focuses on identifying areas at high or intolerable future risk of natural and climate hazards, thereby minimising long-term risk exposure by transferring people, property and assets away from these areas before the impacts of the hazard are experienced. It involves the methodical relocation of property, structures, communities, and vital infrastructure from areas susceptible to environmental threats. Regeneration of retreated areas is a key component to managed relocation. Targeted relocation or retreat involves the selective removal of assets/property from hazard-prone areas, often to make space for resilience or mitigation measures. At its most extensive, retreat can encompass the complete relocation of an entire community. Managed relocation can take a range of forms which can be phased overtime including:

· Voluntary buyouts on open market

· Buyouts with climate leases

· Targeted retreat of built environment

· Retreat of critical infrastructure from vulnerable sites



### Interdependencies

Retreat is an approach best implemented alongside other adaptation measures such as using vacated land for stormwater conveyance or storage opportunities.

SOUTH DUNEDIN FUTURE



## Characteristics

### Pros

- **Efficacy:** Moving exposed assets, people and places from hazards is an effective way of reducing community risk.
- **Generational, flexible solution:** The generational characteristics are dependent on the retreat mechanism, however effective strategies focused on community wellbeing can result in long term benefits that serve multiple generations. It is not flexible given the associated cost and infrastructure associated with reversing any retreat decision.
- **Natural environment:** Minimal direct impact on environmental outcomes, however there is the opportunity to regenerate natural processes and habitats on vacant land post retreat.

### Cons

- **Maintained sense of place/identity:** Retreat will result in a loss of sense of connection to place, particularly for those who have lived in the area for generations. Retreating from important cultural spaces (e.g., rohe moana, urupā) will have significant impacts on Māori communities and may result in a sense of displacement and loss of cultural identity. However, proactively planning for where relocated communities will go allows time to integrate and build attachments to a new location.
- **Cost:** Costs are likely to be very high, but it is unclear how the cost compares to the cost of inaction. Retreat of critical infrastructure and amenities will require upfront investment to enable relocation, however longer-term costs of repair and insurance considerations will be reduced due to decreased risk. Homeowners will require financial support. Greater clarity is expected on how the process can be supported by local/central government and private organisations (like insurers and banks). Given the current lack of clarity, there are risks associated with not having the right decision-makers engaged at the right stage of the process.
- **Social co-benefits:** Displaced people will need to relocate to areas that are available, acceptable and affordable.

### Neutral

- **Social co-benefits:** Retreat will have a generally positive impact on economic and safety metrics; however, the social impacts of moving communities away from their homes cannot be understated, particularly for communities with strong social cohesion and ties to the area. Impacts on renters cannot be overlooked with engagement often only carried out with property or infrastructure owners.
- **Emissions, pollution and material re-use:** It is dependent on relocation strategy but could be low emissions if material re-use is optimised, particularly if existing dwellings can be relocated. There will be carbon requirements associated with upgrading or providing new infrastructure in other locations. However, there may be opportunities to regenerate vacated land to obtain carbon reduction benefits.
- **Technical feasibility and efficacy:** The retreat process can be very complex and have significant challenges (economic, social, cultural) for all partners and stakeholders to ensure a just transition. Addressing knowledge gaps relating to social dynamics and psychological impacts and finding suitable resettlement areas are crucial to facilitate transition. The complex social and economic factors inherent in relocating individuals, communities, or crucial infrastructures makes retreat a long-term strategy with its efficacy largely dependent on the success of the process, particularly the willingness of owners to sell land (assuming a voluntary process) and availability of suitable relocation areas, funding, and incentives to move. Pro-actively retreating allows time for this planning to occur.

## Strategic Considerations

Managed relocation is usually a voluntary process, driven through incentives or risk-based pricing penalisation (e.g. insurance) although aspects of retreat can be mandated (e.g. Public Works). There is likely to be further legislative reform in coming years that will consider retreat implementation. Pro-active retreat is primarily a planning and community centered approach although its success is inextricably linked to where people and property move to (e.g. designating new development zones and developing new infrastructure), and what is done with the hazard effected land in a post-retreat scenario. Implementing retreat strategies in South Dunedin would require careful planning, a deep understanding of local social and economic factors, and meticulous logistical coordination to manage land use transition towards safe zones. Pro-active retreat allows time for this strategic planning to occur.

**Mana whenua can actively participate in the South Dunedin Future programme, including development and assessment of adaptation approaches. The guiding principles in Te Taki Haruru (autaketake, autakata, autūroa, and auora) will be incorporated into the work in consultation with Aukaha and mana whenua to give rise to partnership commitments in the SDF Programme Strategy.**

| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | Dependent on the mechanism of retreat, relocation of communities can create an opportunity to form more resilient urban and community spaces to promote wellbeing and positive environmental outcomes. However, the social and cultural impacts of non-voluntary retreat should not be understated, and effective community engagement and co-design is central to positive wellbeing outcomes. |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | Retreat from at-risk areas provides an opportunity to enhance environmental outcomes through enhanced biodiversity within these spaces. Embracing the concept of kaitiakitaka, retaining these areas as public green space (where practicable) will allow continued access for those with strong connections to the impacted areas and create additional environmental and societal co-benefits through effective planning and design processes. Retreat will potentially significantly impact on cultural connections and ties to the area but could enable culturally appropriate environmental restoration. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | The relocation of residents into existing communities could lead to the loss of social cohesion due to spatial separation. There is also the potential for economic inequities to be magnified as those who cannot afford to live elsewhere or reestablish will have challenges finding a suitable area to move to. However, pro-active retreat enables time to work to address historical injustices, provide economic opportunities in newly relocated areas, ensure access to education and training programs and address ongoing disparities to enable a just transition. |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | Retreat of people, property and assets away from hazardous areas increases the resilience of the community primarily because people and business are less disrupted (both socially and economically). The areas that people and businesses relocate to are beneficiaries of retreat, therefore South Dunedin's resilience is enhanced when relocations within the South Dunedin area are maximized. Other areas outside of South Dunedin may also benefit. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | Relocation enhances the safety and security of individuals and families, reducing the risk of injury and loss of life. In the long term it reduces the stress associated with living in hazardous areas although the social dynamics, psychological impacts and stress associated with retreat are important considerations in both the short, medium and long term. |

# Avoid

## More restrictive building/development standards

**Groundwater**
- ✓ Rising groundwater

**Coastal**
- ✓ Erosion
- ✓ Flooding
- ✗ Tsunami

**Rainfall**
- ✓ Flooding

**Seismic**
- ✓ Earthquake
- ✓ Liquefaction
- ✓ Landslides

## Description

These approaches involve controls on development to reduce exposure and vulnerability to hazards such as earthquakes and coastal flooding. They may include more restrictive standards, development guides, regional and district plan rules, resource consent conditions, bylaws, urban development or growth strategies to mitigate the impact of a hazard. The building code/building consent process could incorporate structural specifications to improve built environment resilience.

Planning provisions or building standards may be introduced on matters like building foundations, drainage systems, setbacks, floor heights, flood proofing, individual on-lot water detention and retention, non-permanent structures, land use coverage or reduced consent durations to regulate activities in areas exposed to hazards. Other areas could see no additional restrictions as a result of natural hazards.


## Interdependencies

More restrictive planning rules or development standards would not reduce risk to existing development but may avoid exacerbating risk. To reduce risk to existing development, other approaches would be required in parallel.

SOUTH DUNEDIN FUTURE



## Characteristics

### Pros

- **Technical feasibility and efficacy:** Feasible to implement to maintain existing levels of exposure, though the plan change process (for change in rules) could be lengthy with hearings and possible appeals. Assuming they become operative in the short-term, their impact would likely not be felt until the medium – long term given delays in implementation through development activities.
- **Health and connection to the natural environment:** Restricting development would help prevent further degradation and avoid future pressures on the natural environment. Depending on the provisions proposed there could be opportunities to enhance the environment.
- **Generational, flexibility:** Planning rules provide flexibility and allow for future changes in scale or approach. By making new developments more durable and resilient, it could extend useable lifetime.

### Cons

- **Social co-benefits:** Improves community resilience in future developments, and thereby future living conditions. There may be inequities in social outcomes dependent on who can afford to be developing land. The rules could result in flow-on impacts on livelihoods.
- **Time:** The ability for plan changes to reduce risk of housing stock over time is dependent on the frequency of the rollover of housing stock.

### Neutral

- **Cost:** Changes to planning provisions would generally fit within normal council spending. However, rules may impose additional costs to community individuals/ landowners in complying with new provisions. By preventing inappropriate development, planning rules may avoid additional future costs in natural hazard event responses.
- **Emissions, pollution and material re-use:** Implementation of planning rules themselves have very little emissions, material or pollution impacts but there may be impacts based on the choice of provisions. This also provides an opportunity to integrate emissions, materials and pollution considerations in the design of adaptation measures.
- **Sense of place / identity:** While these rules would not impact the existing fabric of South Dunedin, it may see reduced desirability and future investment in the area which could degrade the current sense of place and/or identity. On the other hand, it allows the communities to continue to grow and function in a resilient, regulated way.

## Strategic Considerations

Introducing more restrictive planning conditions and rules can be a mechanism to introduce a broad scope of risk reduction options for a variety of natural hazards. The alignment with intended South Dunedin outcomes is largely dependent on the types of provisions implemented (e.g. floor heights, land use coverage, consent durations etc.). There can be a delay for the impact of planning provisions to be operationalized at a scale where it impacts overall risk as they would regulate new activities but not apply to the pre-existing built environment. The applicable areas over which provisions apply will need to be justified by hazard mapping or other evidence which may mean that this approach is better placed to provide resilience to more frequent return period events (with greater data) than preparing for larger scale natural hazard events.

The approach broadly supports social and environmental outcomes but has some challenges in shifting adaptation costs to the community which may exacerbate socioeconomic inequities.

**Mana whenua can actively participate in the South Dunedin Future programme, including development and assessment of adaptation approaches. The guiding principles in Te Taki Haruru (autaketake, autakata, autūroa, and auora) will be incorporated into the work in consultation with Aukaha and mana whenua to give rise to partnership commitments in the SDF Programme Strategy.**

| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | Planning provisions would provide a more regulated and resilient way for the South Dunedin community to continue to grow and function in place. |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | The types of provisions provided as examples are not directly aimed at promoting biodiversity and healthy ecosystems but may have indirect benefits. Restricting unsuitable development may avoid further pressures on the natural environment.<br>Without additional considerations, planning provisions would not provide for Māori/iwi ownership, participation, and empowerment. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | An approach based off restrictions can feel more imposed on communities and would require additional work for it to be participatory and owned by the community. More stringent standards may contribute to gentrification pressures. This may displace longtime residents, disrupt community cohesion and perpetuate socio-economic disparities. |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | This approach would assist in creating a more livable community through requiring new infrastructure and amenities to be more climate-resilient.<br>This approach is less likely to have influence on climate-resilient ventures/businesses other than future infrastructure being more resilient. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | This approach avoids inappropriate future development that would put people at greater risk from natural hazards. Given that provisions would only be applicable for future activities, there may be inequities in outcomes. |

# Avoid

## No new development/redevelopment or change of land use that may exacerbate risk

**Groundwater**
- ✗ Rising groundwater

**Coastal**
- ✓ Erosion
- ✓ Flooding
- ✓ Tsunami

**Rainfall**
- ✓ Flooding

**Seismic**
- ✗ Earthquake
- ✓ Liquefaction
- ✓ Landslides

## Description

Restricting development of land uses through planning rules, can prevent further development and, overtime, reduce exposure to hazards. The aim of this approach is to ensure that any change in the South Dunedin area does not increase risk. This approach may also identify that an area may not be viable for development in the longer term and change the land use in the district plan to enable retreat. This could involve permitting more development in areas of low risk (through intensification or traditional development including outside of South Dunedin), restricting new development and land use changes in high-risk areas, changing land uses to prevent rebuilding, prohibiting landowners from building in flood prone areas all of which could include district plan changes.

This involves several strategies, including the identification of areas at potential risk over the next century, refraining from development in high-risk zones (until / unless risk is sufficiently mitigated), planning provisions to enable retreat, and establishing buffer zones. It also entails zoning high-hazard land for less vulnerable purposes like open space recreation, conservation, or hazard management, with a long-term vision of adapting land-use zones to reduce vulnerability to hazards—such as transforming residential areas into water-compatible developments. Furthermore, it emphasizes avoiding activities that heighten risks and promotes redevelopment approaches that prioritize risk reduction through adaptive management.

**Legend**
- No New Development
- Restrictive Provisions
- No Additional Restrictions


## Interdependencies

Avoiding new development would not reduce risk to existing development but would avoid increasing risk. To reduce risk to existing development, other options would be required in parallel.

SOUTH DUNEDIN FUTURE



## Characteristics

### Pros
- **Cost:** Restricting development in hazard prone areas would require the plan changes (which could be drawn out) but is generally within 'normal' council spend.
- **Emissions, materials, and pollution:** By avoiding new development or redevelopment in hazard-prone areas, there is a reduction in emissions and pollution associated with construction activities and potential ongoing repairs/eventual abandonment of infrastructure. Additionally, there is an opportunity to incorporate sustainable building practices and materials in an alternative location.
- **Health and connection to the natural environment:** Zoning high hazard land for open recreational green spaces can improve community physical and mental health and connection to nature by providing safe areas for outdoor activities and encouraging closer connection to nature.

### Cons
- **Technical feasibility and efficacy:** Feasible but emotive option as it would restrict peoples' rights to redevelop their own property. In the absence of a Climate Change Adaptation Act, existing uses may make this difficult. Community may challenge the removal or restriction of existing use and lose confidence in planning and decision making. Difficult to define acceptable, tolerable and intolerable risks for land use categories.
- **Social co-benefits:** Retrofitting these changes in policy / approach with an existing community is difficult. Particularly when communities are less trusting of change and challenge the veracity of new information identifying a change in risk to that identified / provided for when the development was established.

### Neutral
- **Maintained sense of place/identity:** Avoiding new development or redevelopment can help preserve the unique character and identity of an area as it prevents any new developments from replacing existing sites or landmarks. However, this is assuming proper upkeep of these areas over time to prevent them from losing value and deteriorating.
- **Generational, flexible solution:** No new development/ redevelopment suggests a long-term generational perspective. It also includes actions like allowing more development in safe areas and limiting it in risky ones, adaptable to changing regional conditions illustrating flexibility in the solution.

## Strategic Considerations

This approach, aimed at preventing new development or redevelopment in high hazard zones through effective land use planning, will contribute to a gradual reduction of overall risk to properties and human life within communities. By embracing risk-based planning, it provides an opportunity to move beyond mere preparedness for natural hazards to consider the broader consequences of such events. This approach can provide more holistic outcomes across social resilience, environmental sustainability, cultural preservation, and climate change mitigation and adaptation.

**Mana whenua can actively participate in the South Dunedin Future programme, including development and assessment of adaptation approaches. The guiding principles in Te Taki Haruru (autaketake, autakata, autūroa, and auora) will be incorporated into the work in consultation with Aukaha and mana whenua to give rise to partnership commitments in the SDF Programme Strategy.**

| Strategic Objectives | | Impacts of Approach |
|---|---|---|
| Sustainable urban development | Urban development accounts for the changing environment in South Dunedin, providing better spaces for people, water, and wildlife. | Zoning high-hazard land for less vulnerable purposes like open space recreation and conservation will create thriving and regenerative spaces. Investment in areas of low risk could improve urban form, maximizing health and wellbeing outcomes for communities. |
| Environmental and cultural restoration | Restore and regenerate natural environment, renew urban spaces, and re-energise cultural connections to place. | Restricting redevelopment in high-risk areas can provide opportunities for environmental and cultural restoration. These areas can be converted into green spaces, wetlands, or natural reserves, contributing to the preservation of ecosystems and biodiversity.<br>Allocating resources to low-risk areas offers the potential to create new green spaces, restoring the existing environment and cultural heritage, and enhance water quality. Zoning high hazard land for less vulnerable land uses could create the opportunity of involving the community, including Māori/iwi in the planning and decision-making process for land use and development for shaping the future of these spaces. |
| Just transition | Respond to climate change in ways that empower communities and promote fairness and equity. | Prohibiting development in flood-prone areas in addition to population growth could limit the availability of housing and increase property prices, potentially making it less affordable for some community members.<br>Rezoning land can devalue properties which can exacerbate inequities. |
| Social and economic resilience | Strengthen communities and businesses so they are well-prepared for floods and other hazards, able to cope and recover. | More development in low hazard areas could increase economic opportunities through investment in local businesses, employment opportunities and population growth in the area. |
| Promote community safety | Promote community safety in South Dunedin by reducing flood and other risks, despite increasing natural hazards. | The restriction of development in high-risk areas and investment in development in low-risk areas could encourage more people to move to a safer environment, reducing exposure to hazards and contributing to an increased sense of security. |