volcanic rocks of the Dunedin Volcanic Group. Caversham Sandstone outcrops in the Caversham Valley area, while the overlying Dunedin volcanic rocks form the hills surrounding the harbour and South Dunedin. Younger Quaternary sediments have filled in the area, comprising sands and silts deposited under marine to estuarine conditions, underlain by sandy and gravelly stream sediments. The total thickness of the Quaternary sediments could be as much as 70 m Glassey *et al* (2021). Large accumulations of dune sand have formed along the southern coast between the Pacific Ocean and South Dunedin. Based on groundwater model calibration, the lateral hydraulic conductivities (i.e., a measure of permeability) of the Quaternary sediments are estimated to range from 2 to 6 m/day with vertical hydraulic conductivity estimates to be 10% of the lateral hydraulic conductivity (Chambers *et al*, 2023).

Groundwater enters old wastewater and stormwater pipes according to DCC (2025) and is accidentally providing some groundwater drainage in South Dunedin. Fordyce (2013) observed high salinity in several groundwater monitoring wells, which may have been caused by the accidental groundwater drainage by the old leaky wastewater and stormwater pipes.

The groundwater system in the dunes south of Victoria Rd may be notably different from that in the rest of South Dunedin. There is limited hydrogeological data and information available for the dunes; however, it could be subject to density-dependent groundwater flow processes. Groundwater in the dunes is replenished with fresh rainfall water, and a fresh groundwater body may have formed that floats on top of much denser salt seawater in the marine sediments beneath the dunes. Freeze & Cherry (1979) describe this as the Ghyben-Herzberg principle, which dictates that the depth of the fresh and salt groundwater interface (z) is roughly 40 times the height of the groundwater table (h), as shown in Figure 2. In practice, the interface may not always be as sharp as assumed in the Ghyben-Herzberg principle, but rather a transition zone has formed. ORC (2012) notes that earth resistivity soundings in South Dunedin roughly conformed to the Ghyben-Herzberg ratios for freshwater and saline water in a coastal aquifer.

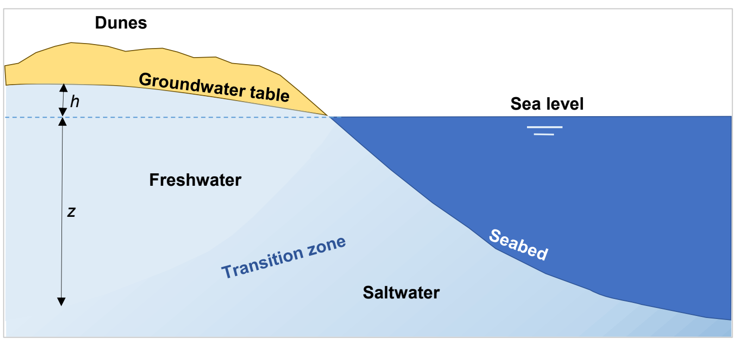

Figure 2: Diagram showing the Ghyben-Herzberg principle

2 APPROACH

2.1 MODELLING TOOLS USED

WSP used the South Dunedin 3-dimensional numerical groundwater model developed by ORC (2012) and updated by GNS (Chambers *et al*, 2023) for the groundwater modelling investigations presented in this report. The key characteristics of this numerical groundwater model are as follows:

- The model is a single layer, steady state model built in MODFLOW. The MODFLOW source code was developed by the USGS (1988). This is a widely used, industry standard, three-dimensional numerical groundwater modelling tool.
- The original model from ORC (2012) was modified and updated by GNS (Chambers *et al*, 2023) as follows:
  - The hydraulic conductivities of the soil materials encountered beneath South Dunedin where optimised in the model, so the model is better capable of simulating recorded groundwater levels. This is an important step in improving the model's accuracy. In addition, GNS improved the estimation of groundwater recharge into the model and optimised the conductance term that governs the flows into the existing leaky stormwater and wastewater network.
  - The model was converted from a 'deterministic' model into a 'stochastic' model. Stochastic modelling involves running the model with various sets of possible hydraulic properties of soil materials, and then analysing the probability of certain outcomes across the various model runs. Instead of simulating a single outcome, a stochastic model simulates the probability that a certain outcome would occur. For example, it simulates the probability of groundwater seepage at the surface causing drainage issues at a certain location and in a certain scenario (e.g., current state or a future state affected by sea level rise). Stochastic modelling aims to capture the uncertainty in groundwater conditions and hydraulic properties of the soil materials.

GNS used the updated model to investigate the probability of the current groundwater drainage issues in South Dunedin being exacerbated due to future sea level rise (Chambers *et al*, 2023).

2.2 MODEL UPDATES

The updated model from GNS (Chambers *et al*, 2023) was further modified by WSP to make it suitable for simulating the efficacy of various groundwater drainage systems to control groundwater levels. The following modifications were made:

- The model was converted to a deterministic model, which means it provides only a single outcome in terms of a groundwater level surface of groundwater flow field for each scenario. This makes it possible to mutually compare the outcomes of various scenarios as described in Section 3. The hydraulic properties and rainfall recharge estimates for the optimised groundwater model by GNS (Chambers *et al*, 2023) were used for the simulations.
- For improved simulation of groundwater gradients, WSP refined the model grid as follows:
  - Reduced grid spacing to 10 m x 10 m (from the original 40 m x 40 m grid) to better simulate groundwater mounding between drainage features. This improves the representation of drainage depth below surface.
  - Increased the number of layers from 1 layer to 4 layers for better simulation of vertical gradients. Each layer has the same lateral and vertical hydraulic conductivity values as the optimised groundwater model by GNS (Chambers *et al*, 2023).
- We rescaled the conductance of pre-existing drainage features in the model (i.e., representing leaky stormwater and wastewater systems) to achieve a consistent water balance with the optimised GNS model (i.e., a uniform conductance value of 0.8 m^2/day was adopted), and assumed new groundwater drainage features would have a conductance twice as high as the leaky stormwater and wastewater systems as they would be specifically designed for groundwater drainage as opposed to the accidental drainage by leaky pipes.

For the assessment of the efficacy testing of the adaptation options (Section 3.2) we used steady state modelling. Steady state modelling assumes the groundwater system is in equilibrium representing average groundwater conditions. We also developed transient (i.e., time dependent) models for high-level assessments of temporal changes in groundwater levels and flows in response to a significant storm event passing the area, or in case of a failure of the pumped scheme which causes groundwater drainage to cease. This is further described in Section 3.4.

2.3 MODEL LIMITATIONS

The South Dunedin 3D numerical groundwater model, built by ORC (2012) and updated by GNS (Chambers *et al*, 2023), has been further adjusted by WSP with the intent to assess changes in groundwater levels and inflows to water management systems as a result of the implementation of various water management adaptation options. However, the model has not specifically been developed to accurately assess groundwater levels and flows at each location at each time. In addition, the model only implicitly accounts for the interaction with stormwater and surface water drainage systems, and does not account for density-dependent flow. The accuracy of the model is limited to the accuracy and completeness of the available hydrogeological and geological data from field investigations and literature, as described in Chambers *et al* (2023). The results presented in this report should therefore be considered as indicative only.

3 OPTIONS ASSESSMENT

3.1 KEY CONSIDERATIONS

Several potential adaptation options are being considered in the SDF programme. The adaptation options entail pumped scheme water management options, because sea level rise will make stormwater and groundwater drainage under gravity unfeasible at some point in time. The leaky pipes from the current stormwater and wastewater network in South Dunedin provide for some 'accidental' groundwater drainage, because those networks are pumped by the Portobello and Tahuna pumpstations. Nonetheless, South Dunedin is already susceptible to stormwater flooding and groundwater drainage issues in the current state, and therefore the adaptation options considered include a short-term solution designed to address current issues. Sea level rise will exacerbate the issues in the future and a sea level rise of up to 1.1 m is assumed to assess the efficacy of the adaptation options in a more distant future (approximately 100 years from the current state).

The potential adaptation options considered assume that the management of stormwater and groundwater will be combined. It should be considered that stormwater flows during significant events are much larger (i.e. multiple orders of magnitude) than groundwater flows, hence the conveyance of groundwater flows has only a minor impact on the stormwater systems design.

A large basin would be built in Forbury Park in the proposed adaptation options, and this basin will be the downstream collection basin where most of the stormwater and drained groundwater will be conveyed. From there, the water will be pumped to the sea by a pumpstation. The pumpstation would have a high-capacity pump that pumps large flows during and directly after significant storm events. A smaller lower-capacity pump would continuously pump water for groundwater drainage. The low-capacity pump is aimed at maintaining the required water level in the basin that allows all stormwater systems to drain to the basin.

It should also be considered that groundwater drainage is continuous (i.e., there is a continuous baseflow) with increased inflows during and directly after storm events and a gradual reduction in flows over several days or weeks thereafter. This is different from stormwater flows that could be very high during and directly after significant storm events but will quickly recede to almost zero during dry conditions. Whilst modelling suggests groundwater inflows could temporarily triple from the baseflows after notable storm events (Section 3.4 and 4.4.2), these flows will always be very modest compared to stormwater flows.

The lowering of groundwater levels by drainage can cause land settlement as a result of reduced pore water pressure and subsequent consolidation of the soil structure. Certain soil materials are particularly vulnerable to settlement, such as unconsolidated and saturated clay and peat, but some land settlement can also occur in sandy and silty soils encountered beneath South Dunedin. Only a modest lowering of the groundwater level across South Dunedin is therefore considered in this investigation, which is generally less than about 0.8 m but locally up to 1.5 m in the adaptation options considered (Section 3.2). This groundwater drawdown is expected to cause less than 50 mm (0.05 m) of land settlement, although further investigations to confirm this are warranted.

3.2 POTENTIAL ADAPTATION OPTIONS CONSIDERED

The following pumped scheme adaptation options (referred to as 'Futures') are considered in the groundwater modelling investigations that aim to increase resilience against groundwater issues:

- **Current systems**: groundwater levels are partially controlled by the current leaky stormwater and wastewater system, which are installed about 1 m deep. This option serves as a comparison, to inform what will happen in the future if no water management changes are implemented.
- **Future 3 – Protect**: improved stormwater and groundwater management with a piped network and in-catchment storage/retention basins installed to a depth of generally 0.8 m, but up to 3 m in some locations. Bespoke infrastructure would be installed that is purposely designed to drain, convey and discharge both stormwater and groundwater effectively. Only limited room for open water at the surface is envisioned, although several storage and retention basins would be installed in Tonga, Bathgate, Forbury and Culling Park. The Tonga, Bathgate and Culling Park retention basins would be designed to avoid interaction with groundwater (i.e., they will be lined or will be installed above the groundwater table). The Forbury Park basin would be excavated and drained to a level of 1 m below the current sea level. The Forbury Park basin would thus drain groundwater, where the other basins would not interact with groundwater. In this option, it is assumed that the drainage provided by the current leaky stormwater and wastewater system will be maintained. This option also includes partially raising the land by 2.5 m in the west of South Dunedin, which provides a greater separation between the ground surface and the groundwater table, thus reducing the exposure to potential groundwater drainage issues.
- **Future 4 – Restore**: this option includes the same stormwater and groundwater management as Future 3, with the addition of open canals that would be constructed in MacAndrew Rd, Bellona St, and Victoria Rd, which would be excavated to a depth of about 1.5 to 3.0 m. The canals proposed in Future 4 should all be fully hydraulically connected to groundwater, so that they are continuously filled with water and drain groundwater (they should not be lined). The open canals also provide for stormwater storage and conveyance. In addition, they form a key opportunity to improve amenity value of South Dunedin by providing for blue and green open spaces in the area.
- **Future 5 – Reshape**: similar to Future 3, this option includes partially raising the land by 2.5 m. In this option the land raising would be in the west and north of South Dunedin. Stormwater and groundwater would be managed the same way as for Future 4.

Overview maps of these three different Futures are included in Appendix A.

For the groundwater modelling the following scenario simulations were developed based on the various options described above, and their outcomes compared as described in Section 4:

- Current State: current sea level and drainage provided by current leaking stormwater and wastewater systems in roads.
- Future 3: current sea level, raised land in the west, a new stormwater system that also drains groundwater, the Forbury Park basin (at -1 m below sea level), and the existing leaky stormwater and wastewater drainage.
- Future 4: current sea level, a new stormwater system that also drains groundwater, the Forbury Park basin (at -1 m below sea level), three new open canals, and the existing leaky stormwater and wastewater drainage.
- Future 5: Stormwater and groundwater managed as per Future 4, and land raising by 2.5 m in west and north of the area.
- Current system with 1.1 m sea level rise: as per Current State but with +1.1 m sea level rise
- Future 3 with 1.1 m sea level rise: as per Future 3 but with +1.1 m sea level rise
- Future 4 with 1.1 m sea level rise: as per Future 4 but with +1.1 m sea level rise
- Future 5 with 1.1 m sea level rise: as per Future 5 but with +1.1 m sea level rise

The results are shown in Appendix B and discussed in Section 4.

3.3 SUCCES CRITERIA

At this stage the only success criteria considered is the required drainage depth, which refers to the depth below which the groundwater level is ideally maintained. The required drainage depth should be selected so that it avoids water ponding at the surface but also avoids moisture ingress into foundations and crawl spaces beneath buildings, and weakening of soils beneath roads and hardstand areas (which can cause road damage such as potholes). For this investigation a required drainage depth of **0.7 m below ground level** was adopted from SBR (2007). This criteria is based on a 'best practice' approach and is used by councils in The Netherlands for managing groundwater levels in urban areas. The criteria accommodates the capillary rise above the groundwater table, annual groundwater table fluctuations, and the depth to underground services and road foundations, which are often about 0.7 m deep (Figure 3). While there is no single report establishing this criteria as a norm, its effectiveness is documented in various technical standard works that describe the interaction between water, soil, and infrastructure.

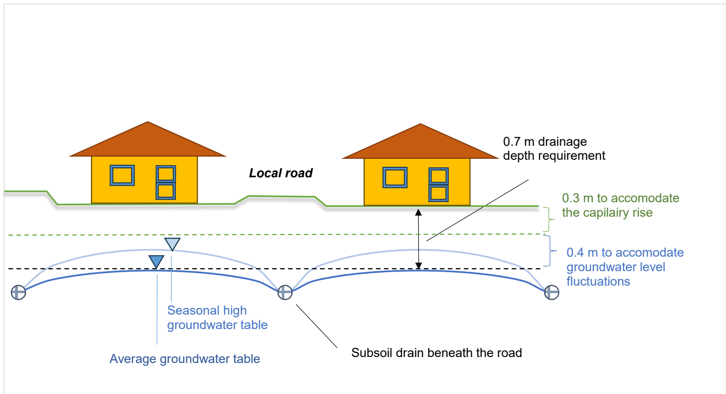

Figure 3: Schematic diagram of required drainage depth

Whilst meeting this success criteria will achieve a liveable area with minimal impacts on buildings, roads and structures, groundwater levels in South Dunedin will always be high and relatively close to the surface. Further lowering the groundwater table by deeper drainage requires more costly pumping and could further increase land settlement, thus it is not recommended.

The high groundwater level also means that the soil's capacity to adsorb rainwater remains very small and that stormwater systems that rely on infiltration to ground, such as soakage pits and infiltration basins, may not be suitable for most of the South Dunedin area.

3.4 EVENT-BASED GROUNDWATER DRAINAGE RESPONSE

The success of the scenarios described above in Section 3.2 are tested for average groundwater conditions. However, during extreme weather events, stormwater and groundwater inflows to the combined stormwater and groundwater systems can rapidly rise and potentially overwhelm the system. Furthermore, pump failure can cause the stormwater and groundwater systems to stop working. Both circumstances can lead to widespread flooding issues.

Indicative transient (i.e., time-dependent) event-based modelling was undertaken to 'stress test' the groundwater management system. This helps to better understand possible groundwater inflows to a pumped combined stormwater and shallow groundwater management system during a major storm event, and how quickly groundwater issues arise after pump failure.

Using the Future 4 scenario with 1.1 m sea level rise, we developed several modelling scenarios with the following key characteristics:

- For the 24-hour storm event we have adopted the 175 mm in 24 hour storm event recorded in June 2015 that resulted in wide-spread flooding in South Dunedin.
- Three different scenarios representing different groundwater recharge rates during the storm event were investigated, with one scenario assuming the combined stormwater and groundwater system can cope with the deluge, and two scenarios in which the system is overwhelmed. In addition, three cases were assessed in which the aquifer storativity[2] varies in one of the scenarios.
- Two different 'pump failure' scenarios were tested (i.e., total cessation of all groundwater drainage, including the drainage provided by the current leaky wastewater and stormwater pipes). With these scenarios we investigated how quickly groundwater levels could rise to the surface and cause water ponding issues due to pump failure. We tested this for a scenario representing average conditions, and for a scenario in which a significant storm event passes the area.

The results are discussed in Section 4.4.2.

As stated, only a high-level event-based modelling was undertaken. We acknowledge further model calibration under transient conditions is required to improve the accuracy of the predictions.

[2] Aquifer storativity represents the volume of water that an aquifer releases from storage under a certain decline in groundwater level (Ritsema, 1994). The aquifer storativity affects the response time of groundwater levels and flows to certain 'stresses', such as increased rainfall recharge or groundwater abstraction through drainage.

4 FINDINGS

4.1 SHORT TERM EFFICACY OF OPTIONS

The first map in Appendix B (slide 1) shows where, in the current state, groundwater levels meet the required drainage depth (i.e., success criteria of 0.7 m below ground level mentioned in Section 3.3). The light-yellow areas do not meet the criteria and are currently susceptible to groundwater drainage issues, even before notable sea level rise has taken effect. The second map in Appendix B (slide 2) shows how the proposed Future 3 stormwater and groundwater systems will notably alleviate the issues, with a much smaller area not meeting the required drainage depth.

The installation of the Forbury Park basin and the new stormwater system that combines stormwater conveyance with groundwater drainage in all three Futures, is expected to achieve a notably improved groundwater outcome in the short term (approximately 10 to 20 years). The partial land raising (by 2.5 m) will improve drainage depth in the west of South Dunedin in Future 3 and 5.

Whilst the Future 4 adaptation option (third map in Appendix B; slide 3), which includes the installation of three canals, will further lower groundwater levels, it may not achieve much more short-term benefits for groundwater outcomes.

4.2 LONG TERM EFFICACY OF OPTIONS

The fourth map in Appendix B (slide 4) shows how almost the entire area of South Dunedin will no longer meet the required drainage depth with a sea level rise of 1.1 m (expected within the next ~100 years) if no adaptation option is implemented (only the existing leaky stormwater and wastewater systems drain some groundwater). Areas that are currently susceptible to drainage issues will have wide-spread persistent water ponding on the surface. Those areas will effectively be uninhabitable swamp areas.

The fifth and sixth map (slide 5 and 6) show the effectiveness of Future 3 and 4 to drain groundwater even when the sea level has risen by 1.1 m. In both options most areas meet the required drainage depth without any persistent water ponding at the surface. However, Future 4 is notably more effective than Future 3 to accommodate the consequences of sea level rise. This is because of the addition of open channels, although we acknowledge that a buried drainage system instead of channels may achieve a similar outcome. Future 5 has the same combined stormwater and groundwater management system as Future 4, but partial land raising (by 2.5 m) will improve drainage depth in the west and north of South Dunedin, as indicated on the seventh and eighth map (slide 7 and 8) in Appendix B.

Compared to the current state (with groundwater levels being controlled solely by a leaky stormwater/wastewater system), the new scenarios may reduce the risks of liquefaction during seismic events because groundwater levels are permanently lowered. Nonetheless, some land subsidence could occur due to the permanent groundwater drainage. Further assessment of the influence on liquefaction and land settlement risks associated with the proposed stormwater and groundwater management in all three Futures is recommended.

Eight cross sections are included in Appendix B following the map series (slide numbers 9 to 16). These provide further insight into how the various drainage features (e.g., stormwater systems, leaky stormwater and wastewater pipes in the roads, basins and canals) will control the groundwater level. It is specifically noted that the drainage features will need to be installed deeper than the required drainage depth of 0.7 m to be sufficiently effective in managing groundwater levels, and this was incorporated in the Future 3, 4 and 5 modelling scenarios (Section 3.2).

4.3 EXPECTED GROUNDWATER FLOWS TO MANAGE

The modelled groundwater balance is shown in Table 1 (note: the modelled groundwater balance has a small discrepancy of ~2% which is common in numerical modelling). The total groundwater recharge from rainfall in the South Dunedin area is estimated to be about 4,900 m^3/day on average, and for this investigation this is assumed to remain the same in the future. In the current state, the groundwater inflows into the existing leaky stormwater and wastewater system are modelled to be about 1,900 m^3/day. The modelling shows this accidental groundwater drainage is causing a small amount of saline intrusion (i.e., saltwater draw-in from the sea) of about 50 m^3/day. The remaining 2,900 m^3/day flows out via groundwater to the sea.

Table 1: Modelled groundwater balance for the current state and future scenarios ('SLR' stands for sea level rise)

Water balance component	Current State	Future 3 - current	Future 4 & 5 - current	Current system + 1.1 m SLR	Future 3 +1.1 m SLR	Future 4 & 5 + 1.1 m SLR
Inflows (m^3/day)						
Rainfall recharge	4,915	4,915	4,915	4,915	4,915	4,915
Inflows from the sea (saline intrusion)	52	321	465	262	1,016	1,516
Total inflows	4,967	5,237	5,381	5,177	5,932	6,431
Outflows (m^3/day)						
Pre-existing road drainage	1,934	907	291	2,693	951	377
New stormwater system	-	1,060	786	-	1,700	1,046
Forbury Park pond	-	733	573	-	1,044	809
Bellona St canal	-	-	316	-	-	359
MacAndrew Rd canal	-	-	390	-	-	440
Nile St canal	-	-	155	-	-	178
Courtney St canal	-	-	100	-	-	162
Victoria Rd canal	-	-	518	-	-	884
Total drainage	1,934	2,699	3,129	2,693	3,696	4,256
Outflows to the sea (via groundwater)	2,917	2,421	2,216	2,401	2,179	2,058
Total outflows	4,851	5,120	5,346	5,095	5,874	6,315

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In all adaptation options (Future 3, 4 and 5), if these were implemented in the next decade (short term), the amount of groundwater inflows into the water management systems (i.e., combined stormwater and groundwater drainage) will increase notably to about 2,700 m^3/day in Future 3 and 3,100 m^3/day in Future 4 and 5 according to the modelling. As a consequence, saline intrusion will increase exponentially.

In a climate-changed future with sea level rise of 1.1 m, the amount of groundwater drainage to the stormwater and groundwater drainage systems will increase notably, up to 4,300 m^3/day on average for Future 4 and 5. However, the percentage difference between the three scenarios with sea level rise is the same as for those without sea level rise. Saline intrusion will become considerable with sea level rise of 1.1 m and is expected to contribute 25 to 50% to the groundwater inflows into the stormwater and groundwater management systems.

Inflows from the sea (i.e., saline intrusion) will be about one third larger in Future 4 and 5 than in Future 3, both in the short and long term (Table 1). This is mainly due to the proposed Victoria Rd canal in Future 4 and 5, which will capture most of the inflows from the sea because it is closest to the coast. This also means that much of the saline intrusion would be contained by the Victoria Rd canal, minimising saltwater inflows to the rest of the stormwater and groundwater management system.

4.4 OTHER CONSIDERATIONS

4.4.1 GROUNDWATER QUALITY

As described above in Section 4.3, saline intrusion will increase exponentially across all the scenarios considered (including those without adaptation options implemented) further increasing the existing salinity of the shallow groundwater in South Dunedin. The proposed Forbury Park basin and the Future 4 and 5 canals will become brackish or even saline. The change in salinity and overall water quality will likely influence ecological values in the proposed open water drainage features. The planting of salt tolerant vegetation along open water features is recommended, also noting that brackish water could flood land adjacent to the open water features during a significant storm event. In addition, existing underground services (e.g., cables, pipes, fittings, manholes, etc.) could be affected by the salt water, depending on the materials they are made of. Salt tolerant materials should be used for new underground services installations. What the exact impacts are and whether these are negative is still to be investigated.

4.4.2 OPERATION AND MAINTENANCE

Ongoing and continuous pumping will be required in all scenarios to drain the land from stormwater and groundwater. This means that ongoing operation and maintenance costs will be incurred to keep South Dunedin dry, and these costs are expected to increase over time as more pumping will be required with progressive sea level rise.

It should also be considered that continuous pumping to drain stormwater and groundwater is already taking place in many urban areas and several rural areas across New Zealand, and the world. This will likely increase in the future, and proper operation and maintenance of water management systems will become increasingly more important as well as costly.

South Dunedin is not unique in its vulnerability to stormwater flooding and groundwater drainage issues and both technical and management solutions for designs, operation and maintenance of water management systems could be adopted from international case studies where these have been successfully implemented (Golder and Deltares, 2017).

To better understand the operational vulnerability of the proposed combined stormwater and groundwater management system, we investigated how much groundwater inflows to the system could increase during a significant storm event, and whether this could overwhelm the system. In addition, we assessed how groundwater levels respond to a failure of the pumping system, and within what timeframe this could lead to widespread drainage issues in South Dunedin. The key findings are as follows:

- The proposed combined stormwater and groundwater management system is designed to cope with significant storm events, which is referred to as 'design events'. High-level modelling assessments suggest groundwater peak inflows to the system could increase from 0.05 to 0.17 m^3/sec (or from 5,000 to about 15,000 m^3/day) during those design events, assuming that the system copes and no wide-spread surface flooding occurs. The groundwater peak flow is notably less than the peak stormwater inflow to the proposed Forbury Park basin in a 1 in 100 year storm event, which is 7.5 m^3/sec. It is unlikely that groundwater inflows could overwhelm the stormwater conveyance systems during design events, noting that the proposed combined stormwater and groundwater management system was designed to accommodate the combined groundwater and storm water peak inflows.
- Pump failure will cause groundwater levels to gradually rise reducing the drainage depth. Eventually, the area's drainage depth will resemble the unmitigated drainage depth shown in Map 1 and 4 in Appendix B with widespread drainage issues. The modelling assessment suggest that pump failure would not immediately lead to significant groundwater issues and there will in most circumstances be sufficient time to restore the pumping scheme and avoid issue associated with groundwater levels (i.e., water ponding on the surface). If conditions are relatively dry (only moderate rainfall), it could take more than a year for groundwater levels to reach the surface in susceptible areas. Groundwater levels can reach the surface more rapidly if conditions are wet, although it would still take several months for groundwater issues in the area to be widespread. However, this is heavily dependent on the antecedent conditions. If pump failure occurs during or immediately following significant rainfall and widespread surface flooding, groundwater issues could arise immediately.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

South Dunedin is highly vulnerable to flooding and drainage issues due to its low elevation (less than 3 m above sea level) and high groundwater levels (often <1 m below ground). Existing leaky stormwater and wastewater pipes provide some accidental groundwater drainage, but this is insufficient even now. Sea level rise (up to +1.1 m within ~100 years) will make gravity drainage unfeasible. Without intervention, most of South Dunedin will become persistently waterlogged and effectively uninhabitable.

Several future adaptation options have been considered in this groundwater modelling investigation aimed at alleviating stormwater flooding and groundwater drainage issues:

- Current system: Groundwater drainage is only provided by the current leaky stormwater and wastewater system.
- Future 3 – Protect: New piped stormwater system that drains into a Forbury Park basin (excavated into groundwater and with water level maintain at 1 m below sea level), and partial land raising in the west by 2.5 m.
- Future 4 – Restore: Same stormwater and groundwater management as Future 3, but with the addition of open canals (MacAndrew Rd, Bellona St, Victoria Rd) which provides better groundwater drainage and achieves amenity improvements. However, there would be no land raising in this option.
- Future 5 – Reshape: Same as Future 4, but with partially raising the land by 2.5 m in both the west and north of South Dunedin. This option is a hybrid form between Futures 3 and 4, but with additional land raising in the north.

The effectiveness of the investigated future adaptation scenarios is as follows:

- For the short term (10–20 years), Future 3 significantly reduces groundwater issues compared to the current state. Whilst Future 4 and 5 achieve the same, they offer only marginal additional short-term benefit in comparison to Future 3.
- For the long term which includes +1.1 m sea level rise, the current system will fail to provide any meaningful groundwater drainage. Future 3, 4 and 5 are all able to maintain a required drainage depth (0.7 m below ground), preventing surface ponding. In contrast to the short term outcomes, Future 4 and 5 are notably more effective than Future 3 under +1.1 m sea level rise conditions, mainly due to the addition of the Victoria Rd canal in these Futures.

The current accidental groundwater inflow (i.e., drainage) to the leaky stormwater and wastewater system is modelled to be ~1,900 m^3/day. Under current conditions groundwater inflows to the Future 3 water management systems are modelled to be ~2,700 m^3/day, and for Future 4 and 5 ~3,100 m^3/day. The latter will increase to more than 4,300 m^3/day with 1.1 m sea level rise. Saline intrusion will increase significantly, especially with sea level rise (up to 50% of all groundwater inflows to the water management systems).

Overall Conclusion:

- Pumped drainage systems are essential for South Dunedin's future resilience, which are needed to maintain groundwater levels sufficiently below the ground surface in areas that are currently about 2 m below sea level.
- Future 4 (with canals) and Future 5 (same as Future 4, but with partial land raising) provide the best long-term solution for managing groundwater and enhancing amenity, despite higher complexity and cost.
- All options will require ongoing pumping and maintenance, and saline intrusion will be a major factor in future system design.
- Whilst several recommendations for further investigations are outlined in Section 5.2, we are confident that at this stage a sufficient level of knowledge is available to understand how South Dunedin's groundwater system can be effectively managed.

5.2 RECOMMENDATIONS

Several further investigations are recommended to better understand the benefits and pitfalls of the proposed water management adaptation options. The recommendations are listed below with an indication of the level of priority and possible timeline for implementation:

High priority, short term (1-5 years)

- Initiate a pilot trial in which a small-scale groundwater drainage system is installed and tested. Groundwater levels and drainage inflows should be monitored prior to, during and after testing. Groundwater salinity monitoring (in monitoring wells and in the drainage water) is also recommended. This provides valuable information on aquifer permeability, zone of influence of the drainage system, and further insights into the efficacy of groundwater drainage solutions. A pilot trial groundwater drainage test also provides an opportunity for DCC staff and stakeholders to become familiar the concept of groundwater drainage and with the systems involved. We recommend a well-thought-out pilot trial plan is drafted in which the objectives, approach and programme of such a test are clearly described.
- Open water features (Forbury Park basin and proposed canals) will likely become brackish or even saline over time, in all scenarios investigated. The ecological impacts need further assessment, which will inform the design, landscaping (e.g., planting of salt tolerant vegetation) and long-term maintenance of the proposed open water features. Underground services (e.g., cables, pipes, fittings, manholes, etc.) could be affected by salt water, depending on the materials they are made of. A review of ways to mitigate saltwater corrosion of underground services (e.g., use of type of materials) for new underground services installations is recommended.
- Land settlement risks are expected to be minor (<50 mm) due to modest groundwater lowering of the proposed systems (i.e., generally no more than 0.8 m drawdown). However, more detailed investigations are recommended to confirm the magnitude of land settlement and what mitigation options could be considered if this is required.
- An integrated pumped groundwater and stormwater management system will have notable specific design implications (e.g., saline intrusion, varying pump regimes for dry-weather and for storm event control, etc.). An holistic multi-disciplinary approach is required to develop a robust suitable future-ready design of the stormwater and groundwater management system.
- The potential adaptation options considered all require a pumped scheme to be implemented, and this requires ongoing operational and maintenance efforts and costs, which are likely to increase considerably

over time when the consequences of climate change and sea level rise become considerable. A comprehensive cost-benefit analysis is recommended based on further design work.

Low priority, long-term (>5 years)

- The saline intrusion that already occurs beneath South Dunedin and likely to increase in the future could be strongly driven by density-dependent flow. This process is currently not explicitly incorporated in the numerical groundwater modelling undertaken to date. Further modelling investigations to improve the understanding of saline intrusion and groundwater processes beneath the dune areas is recommended. These would inform the timeline within which a future stormwater and groundwater management system will become saline, and what measures are most effective to partially mitigate the saline intrusion. This may inform long-term decision making in relation to the stormwater and groundwater management of the area.
- Further investigations into the temporal changes in groundwater levels and flows in response to a significant storm event passing the area, or in case of a failure of the pumped scheme which causes groundwater drainage to cease, could be considered. Transient model calibration is required to confirm representative aquifer storativities to increase the accuracy of the model predictions. However, this may not impact design choices as a combined stormwater and groundwater management system will be designed to accommodate much higher stormwater flows.
- The permanent lowering of the groundwater table by the considered adaptation options could potentially reduce liquefaction effects, and further high-level investigation in the beneficial effects on liquefaction is recommended. However, this investigation may not be required to inform further design work for the pumped stormwater and groundwater management system.
- Additional modelling assuming various sea level rise conditions (i.e., associated with different sea level rise predictions and at different time steps) is recommended to better understand when the tipping points occur at which the subsequent stages of adaptation options are best implemented. Earth Sciences New Zealand (ESNZ) indicated they could provide improved high-resolution vertical land movement estimates to help inform this investigation. This may inform long-term decision making in relation to the stormwater and groundwater management of the area.

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7 DISCLAIMER AND LIMITATIONS

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This report ('**Report**') has been prepared by WSP (via the Kia Rōpine group) exclusively for the South Dunedin Future Programme team (Dunedin City Council and Otago Regional Council) ('**Client**') in relation to the South Dunedin Future Programme – groundwater drainage modelling assessment of shortlisted potential adaptation options for Phase 3.4 - Spatial Short List of Adaptation Options ('**Purpose**') and in accordance with the Agreement. The findings in this Report are based on and are subject to the assumptions specified in the Report, the Agreement and associated attachments, and Client Data supplied during the data request phase. WSP accepts no liability whatsoever for any use or reliance on this Report, in whole or in part, for any purpose other than the Purpose or for any use or reliance on this Report by any third party.

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APPENDIX A – GROUNDWATER DRAINAGE OPTIONS MAPS


Current State - Drainage Features
Cross section lines
Drainage features (current state)
Topography (m above DDB)
255
0
A
A'
B
B'
C
C'
D
D'
Maryhill
Kensington
The Glen
Cargills Corner
South Dunedin
Forbury Corner
Saint Kilda
Sunshine
Rawhiti St
Musselburgh Rise
Musselburgh
Tainui
Chisholm Park
St Kilda Kindergarten
Ocean Beach Domain
John Wilson Ocean Dr
Portsmouth Dr
Allandale Rd
Easther Cres
Hillside Rd
Macandrew Rd
Fawcett St
Melbourne St
Oxford St
Bay View Rd
Kings Ave
Bayfield Rd
Arawa St
N
250 125 0 250 500 750 1,000
Meters

1

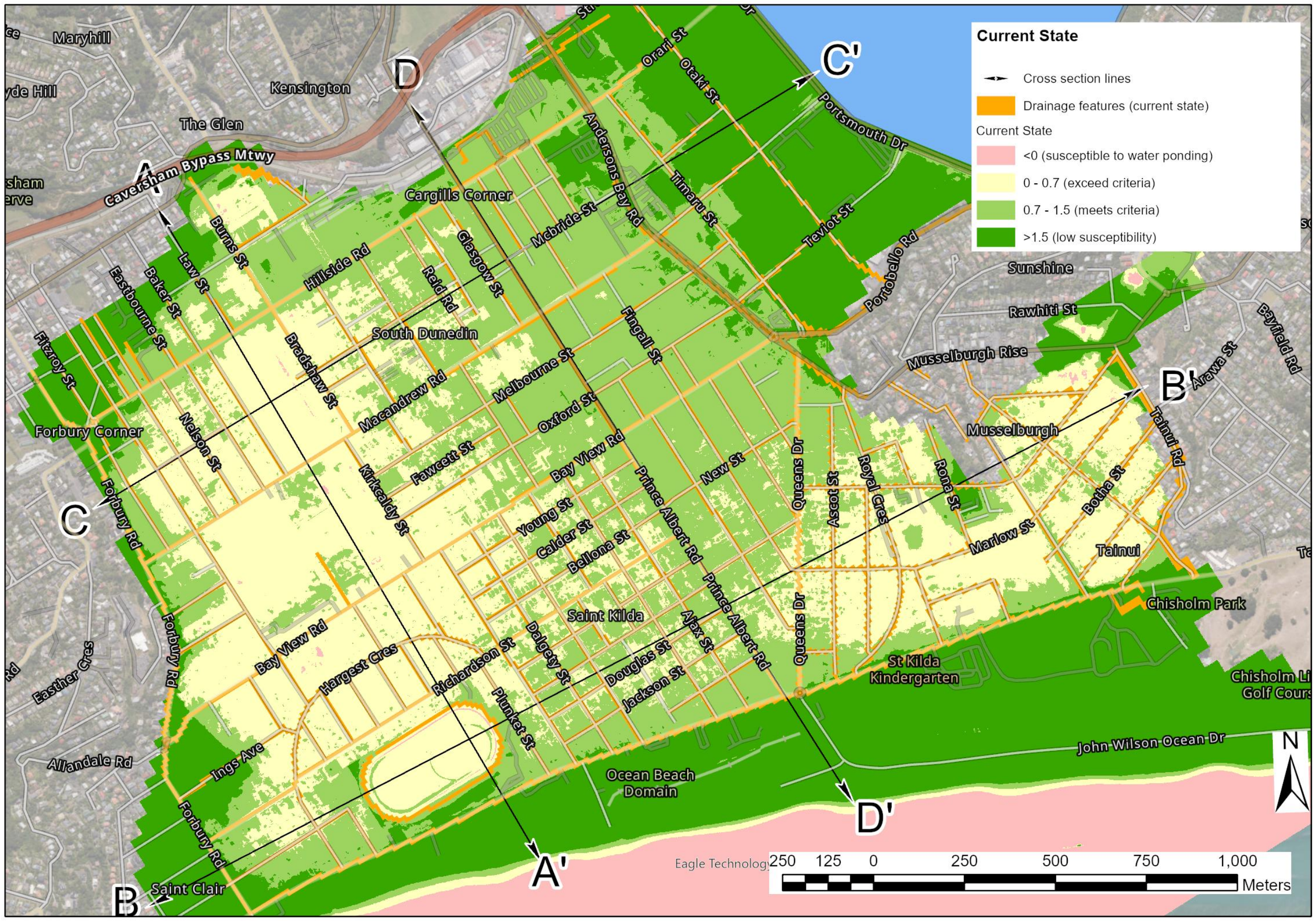

Future 3 - Drainage Features
Cross section lines
Future 3 - raised land
Forbury Park pond
Drainage features (current state)
Short term pipes
Topography (m above DDB)
255
0
Forbury Park pond
(1 m below sea level)
A
A'
B
B'
C
C'
D
D'
Maryhill
Kensington
The Glen
Caversham Bypass Mtwy
Cargills Corner
South Dunedin
Forbury Corner
Saint Kilda
Saint Clair
Musselburgh
Tainui
Chisholm Park
St Kilda Kindergarten
Ocean Beach Domain
John Wilson Ocean Dr
250 125 0 250 500 750 1,000
Meters
N

2

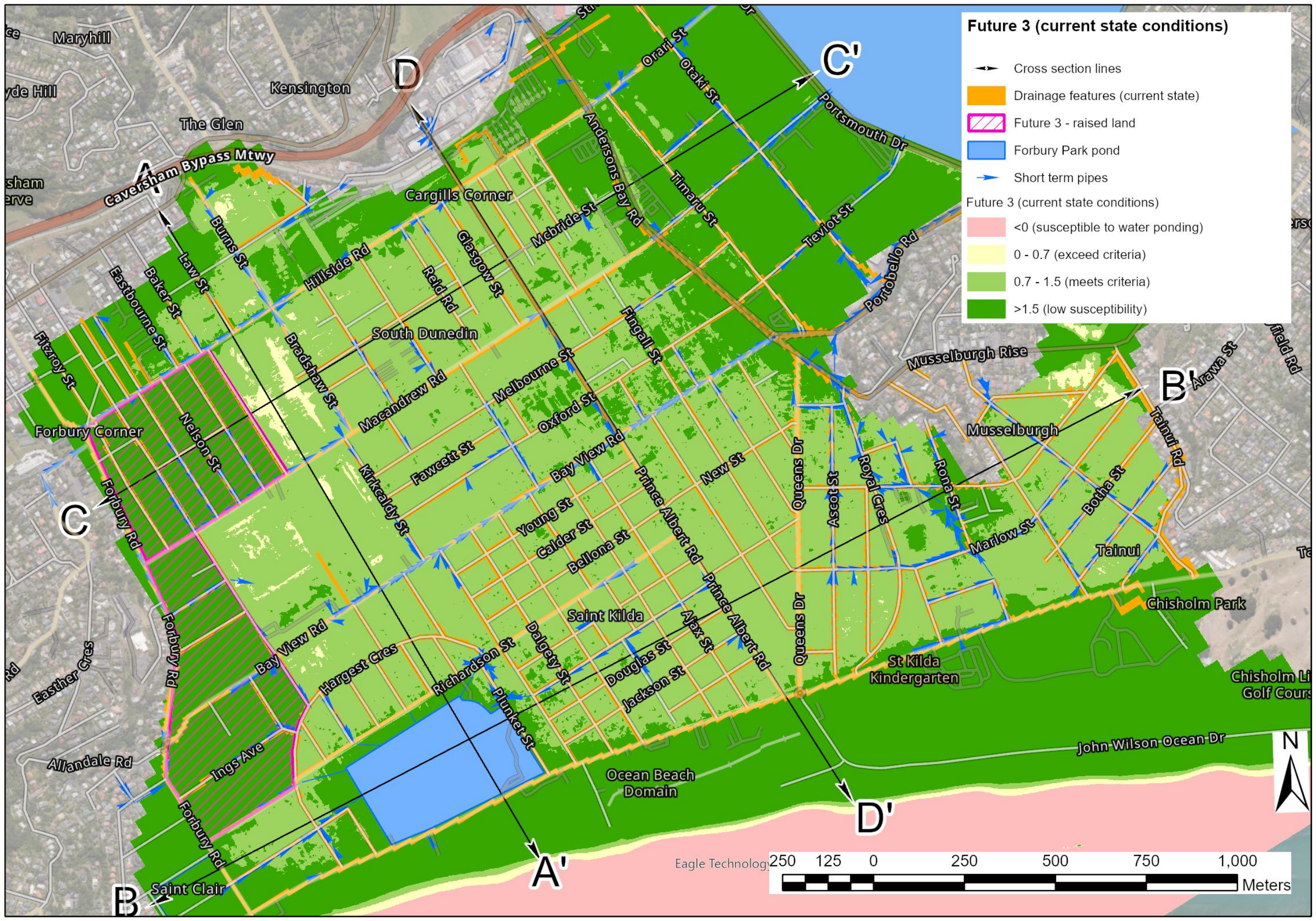

Future 4&5 - Drainage Features
Cross section lines
Future 5 - raised land
Forbury Park pond
Drainage features (current state)
New canals
Short term pipes
Topography (m above DDB)
255
0
A
A'
B
B'
C
C'
D
D'
MacAndrew canal (0.6 m below sea level)
Bellona canal (0.8 m below sea level)
West canal (1 m below sea level)
Coughtrey canal (0 to 1 m below sea level)
Forbury Park pond (1 m below sea level)
Victoria canal (0 to 1 m below sea level)
Maryhill
Kensington
The Glen
Cargills Corner
Forbury Corner
Saint Kilda
Musselburgh
Musselburgh Rise
Tainui
Chisholm Park
St Kilda Kindergarten
Ocean Beach Domain
Saint Clair
John Wilson Ocean Dr
Portsmouth Dr
Portobello Rd
N
250 125 0 250 500 750 1,000
Meters

3

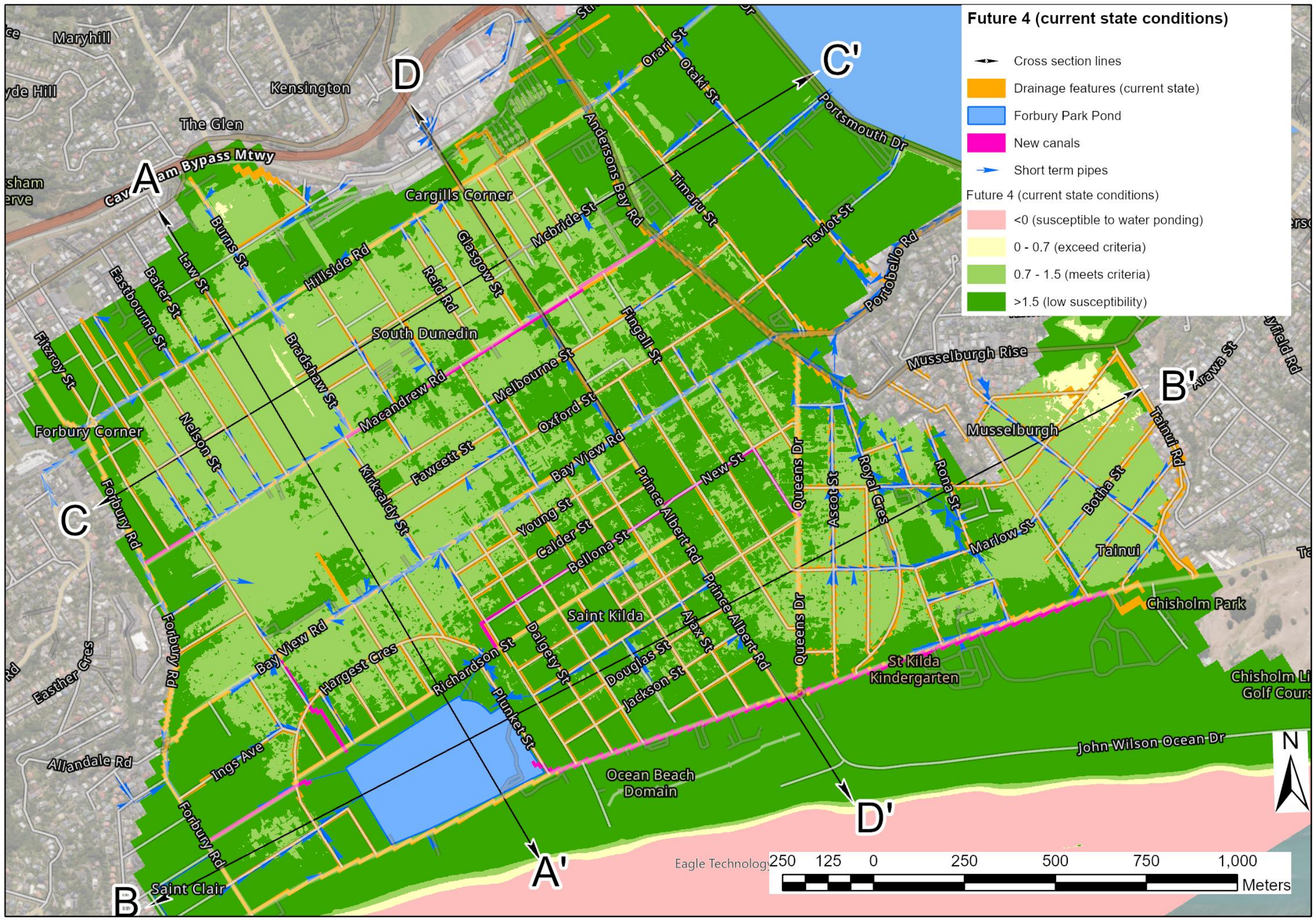
APPENDIX B – GROUNDWATER DRAINAGE RESULTS MAPS AND CROSS SECTIONS


Current State
Cross section lines
Drainage features (current state)
Current State
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
South Dunedin
Saint Kilda
Musselburgh
Forbury Corner
Cargills Corner
Ocean Beach Domain
St Kilda Kindergarten
Chisholm Park
Tainui
Saint Clair
Caversham Bypass Mtwy
Kensington
The Glen
Maryhill
Sunshine
Eagle Technology
250 125 0 250 500 750 1,000
Meters
N

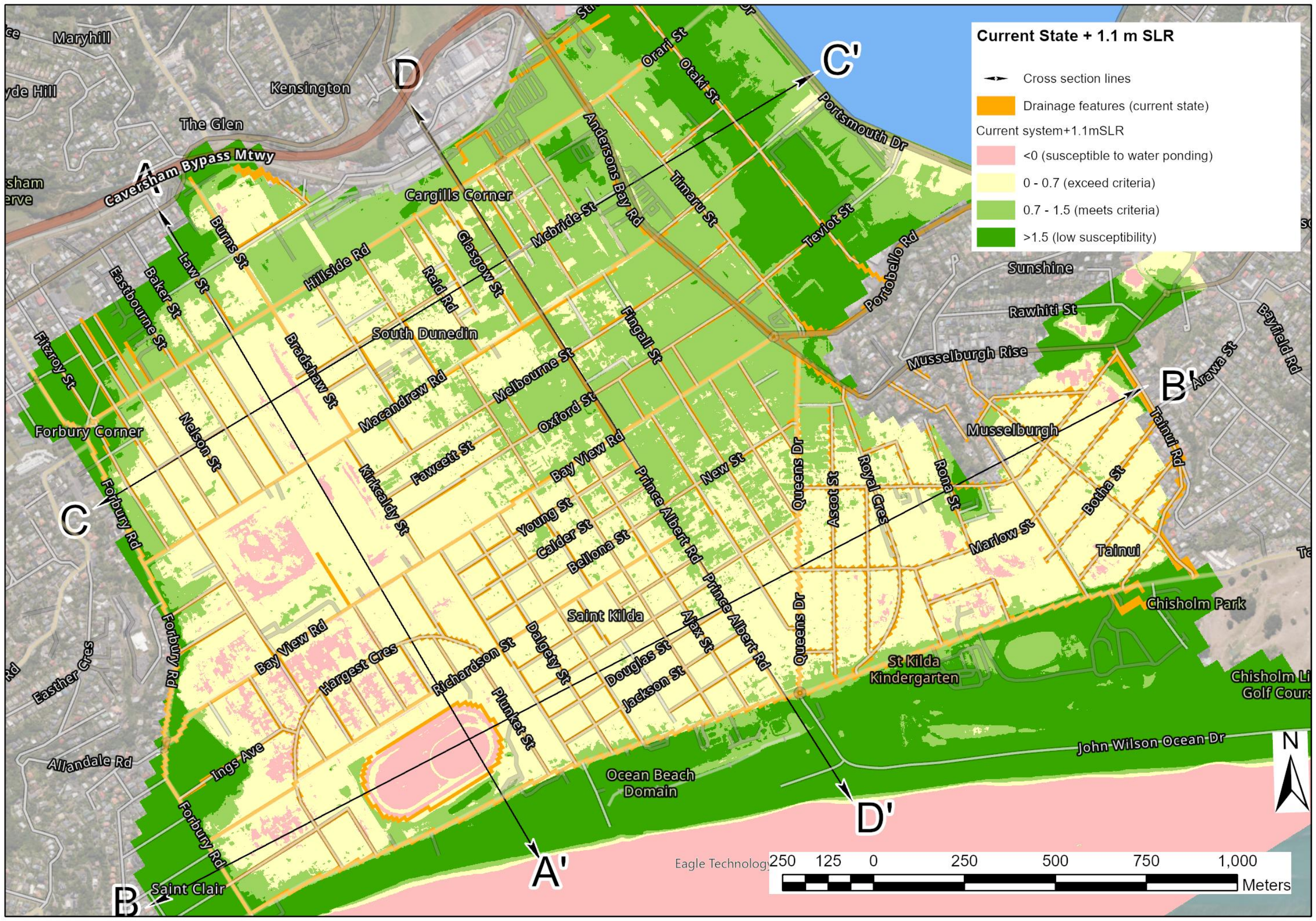
1


Future 3 (current state conditions)
Cross section lines
Drainage features (current state)
Future 3 - raised land
Forbury Park pond
Short term pipes
Future 3 (current state conditions)
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
Maryhill
Kensington
The Glen
Caversham Bypass Mtwy
Cargills Corner
South Dunedin
Forbury Corner
Saint Kilda
Musselburgh
Musselburgh Rise
Tainui
Chisholm Park
St Kilda Kindergarten
Ocean Beach Domain
Saint Clair
John Wilson Ocean Dr
Portsmouth Dr
Hillside Rd
Bay View Rd
Macandrew Rd
Prince Albert Rd
Queens Dr
Forbury Rd
Richardson St
Hargest Cres
Ings Ave
Allandale Rd
N
250 125 0 250 500 750 1,000
Meters
Eagle Technolog

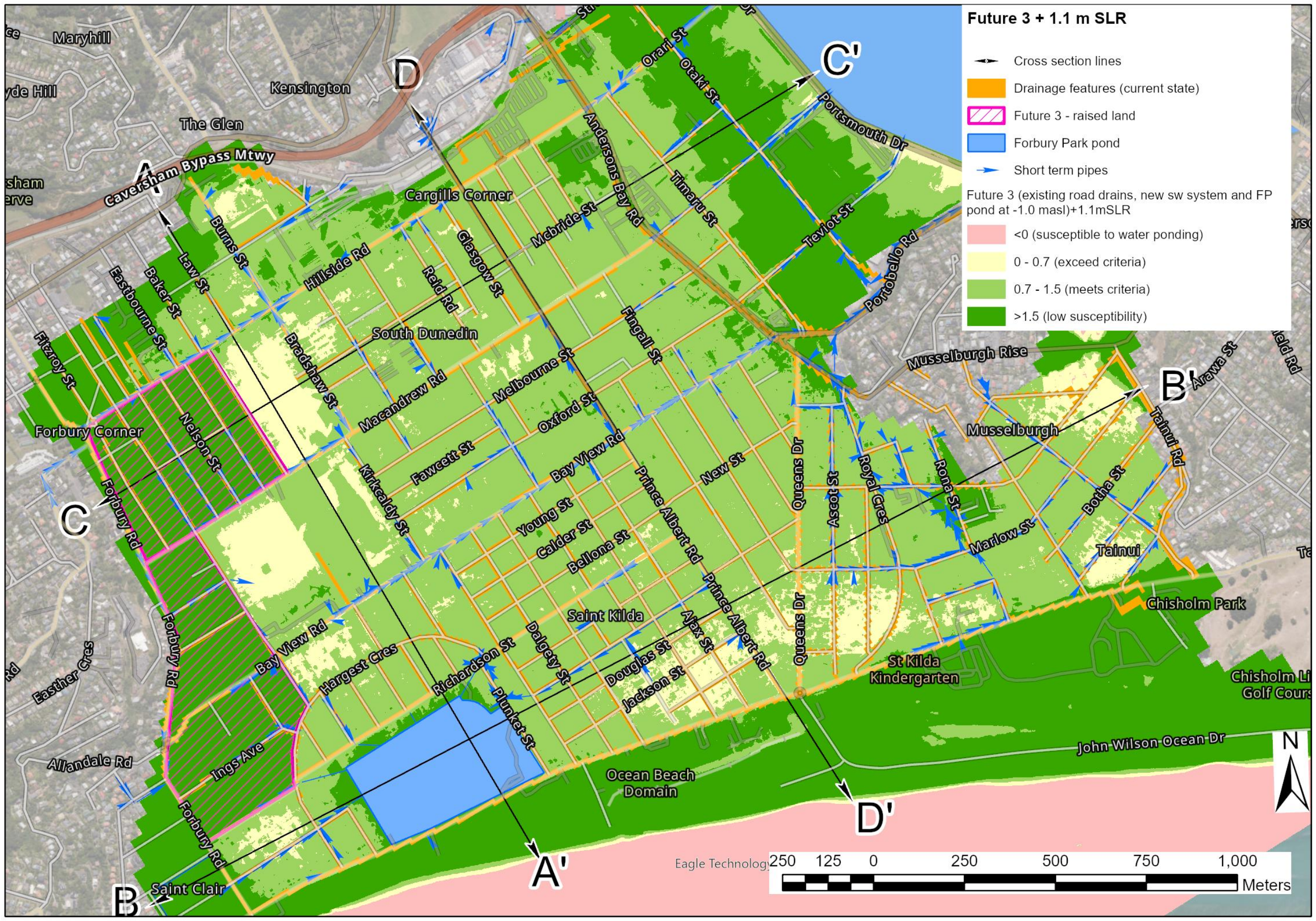
2


Future 4 (current state conditions)
Cross section lines
Drainage features (current state)
Forbury Park Pond
New canals
Short term pipes
Future 4 (current state conditions)
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
N
250 125 0 250 500 750 1,000
Meters
Maryhill
Kensington
The Glen
Cargills Corner
South Dunedin
Forbury Corner
Musselburgh Rise
Musselburgh
Tainui
Chisholm Park
Saint Kilda
St Kilda Kindergarten
Ocean Beach Domain
Saint Clair
John Wilson Ocean Dr
Portsmouth Dr
Portobello Rd
Hillside Rd
Macandrew Rd
Bay View Rd
Prince Albert Rd
Queens Dr
Forbury Rd
Eagle Technology

3

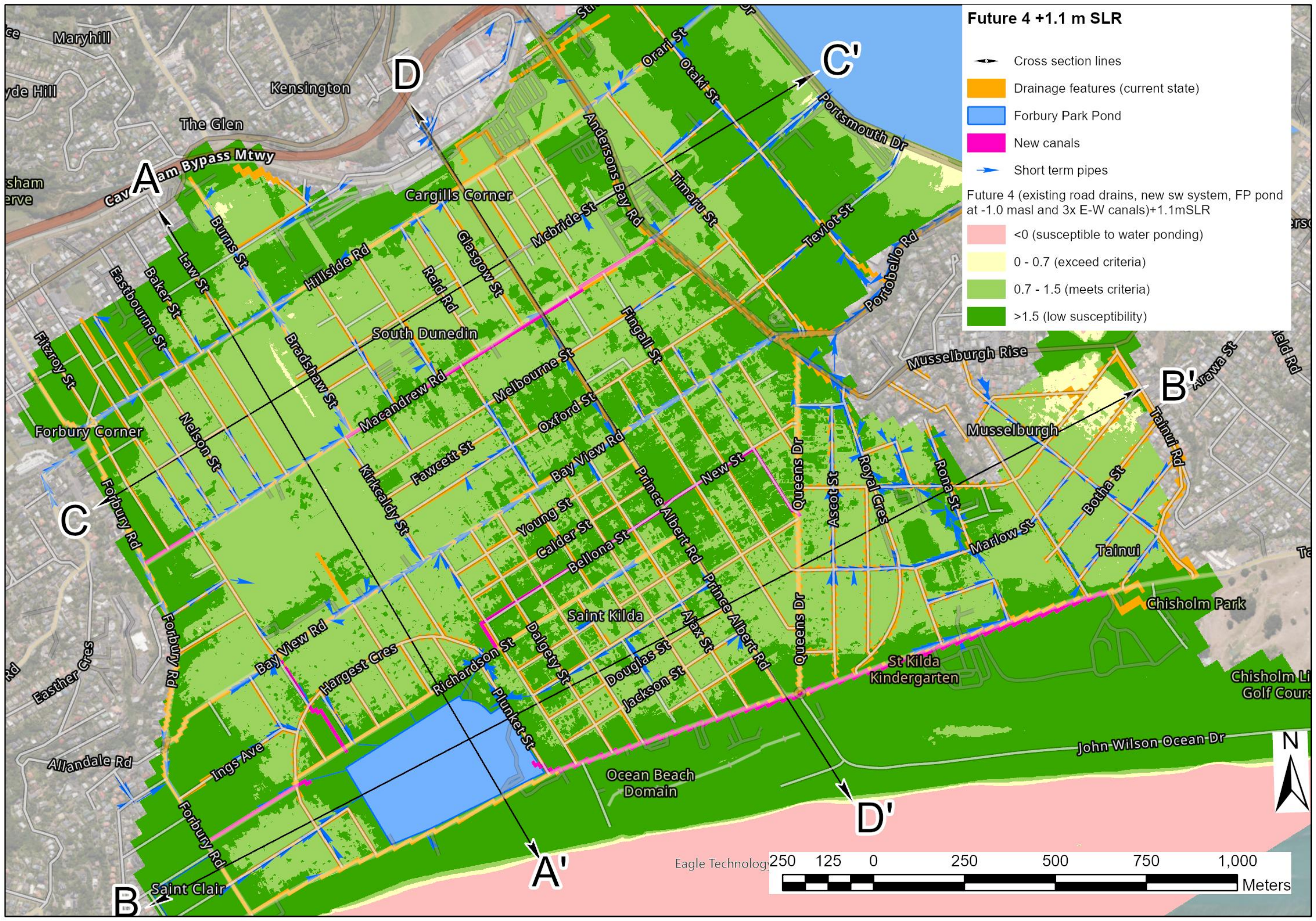

Current State + 1.1 m SLR
Cross section lines
Drainage features (current state)
Current system+1.1mSLR
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
N
250 125 0 250 500 750 1,000
Meters
Eagle Technology
Maryhill
Kensington
The Glen
Caversham Bypass Mtwy
Cargills Corner
South Dunedin
Forbury Corner
Saint Kilda
Musselburgh
Sunshine
Rawhiti St
Musselburgh Rise
Tainui
Chisholm Park
St Kilda Kindergarten
Ocean Beach Domain
John Wilson Ocean Dr
Saint Clair
Portsmouth Dr
Portobello Rd
Teviot St
Timaru St
Otaki St
Orari St
Andersons Bay Rd
Mcbride St
Glasgow St
Reid Rd
Hillside Rd
Burns St
Law St
Baker St
Eastbourne St
Fitzroy St
Nelson St
Bradshaw St
Macandrew Rd
Melbourne St
Fingall St
Oxford St
Fawcett St
Kirkcaldy St
Bay View Rd
Young St
Calder St
Bellona St
Prince Albert Rd
New St
Queens Dr
Ascot St
Royal Cres
Rona St
Marlow St
Botha St
Tainui Rd
Arawa St
Bayfield Rd
Forbury Rd
Easther Cres
Allandale Rd
Ings Ave
Hargest Cres
Richardson St
Plunket St
Dalgety St
Douglas St
Jackson St
Ajax St

4

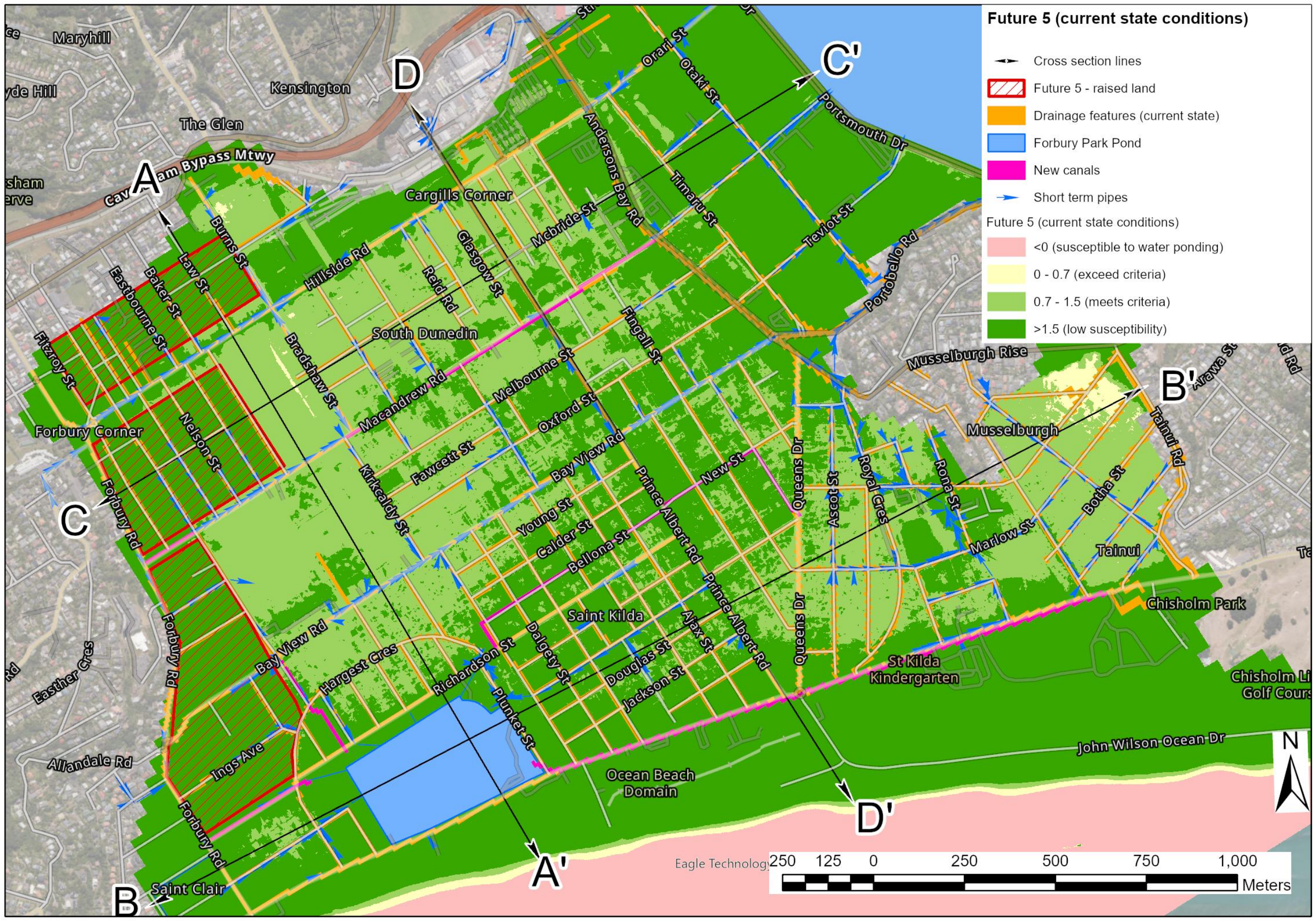


Future 3 + 1.1 m SLR
Cross section lines
Drainage features (current state)
Future 3 - raised land
Forbury Park pond
Short term pipes
Future 3 (existing road drains, new sw system and FP pond at -1.0 masl)+1.1mSLR
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
250 125 0 250 500 750 1,000
Meters
N

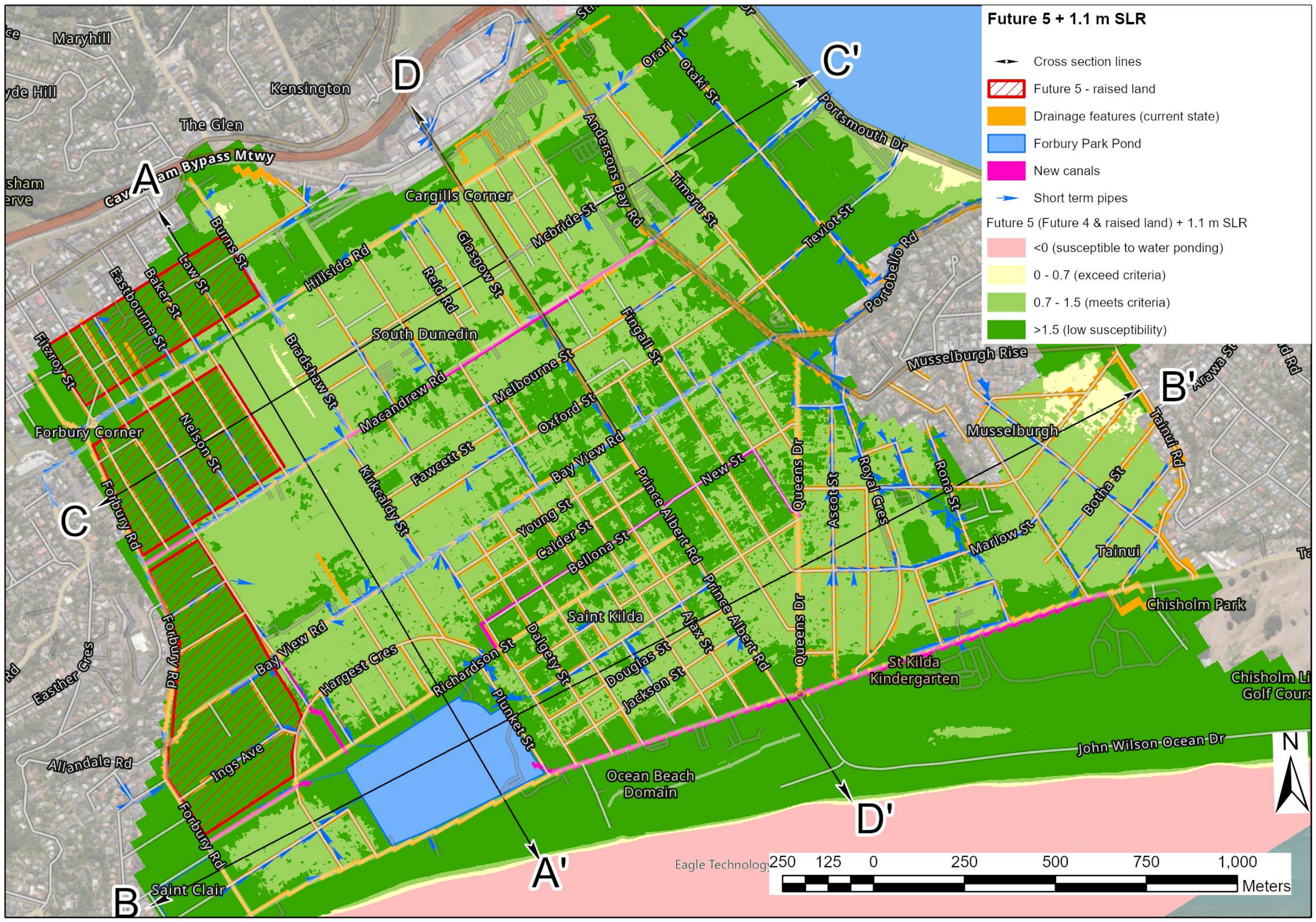
5


Future 4 +1.1 m SLR
Cross section lines
Drainage features (current state)
Forbury Park Pond
New canals
Short term pipes
Future 4 (existing road drains, new sw system, FP pond at -1.0 masl and 3x E-W canals)+1.1mSLR
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
South Dunedin
Saint Kilda
Musselburgh
Forbury Corner
Cargills Corner
Saint Clair
Kensington
The Glen
Maryhill
Ocean Beach Domain
Chisholm Park
St Kilda Kindergarten
John Wilson Ocean Dr
250 125 0 250 500 750 1,000
Meters
N

6

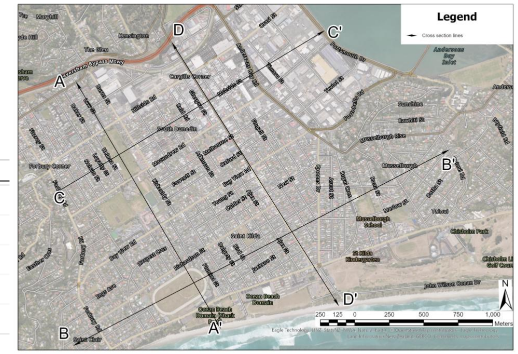

Future 5 (current state conditions)
Cross section lines
Future 5 - raised land
Drainage features (current state)
Forbury Park Pond
New canals
Short term pipes
Future 5 (current state conditions)
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
South Dunedin
Saint Kilda
Musselburgh
Forbury Corner
Cargills Corner
Kensington
The Glen
Maryhill
Tainui
Chisholm Park
St Kilda Kindergarten
Ocean Beach Domain
Saint Clair
Eagle Technology
250 125 0 250 500 750 1,000
Meters
N

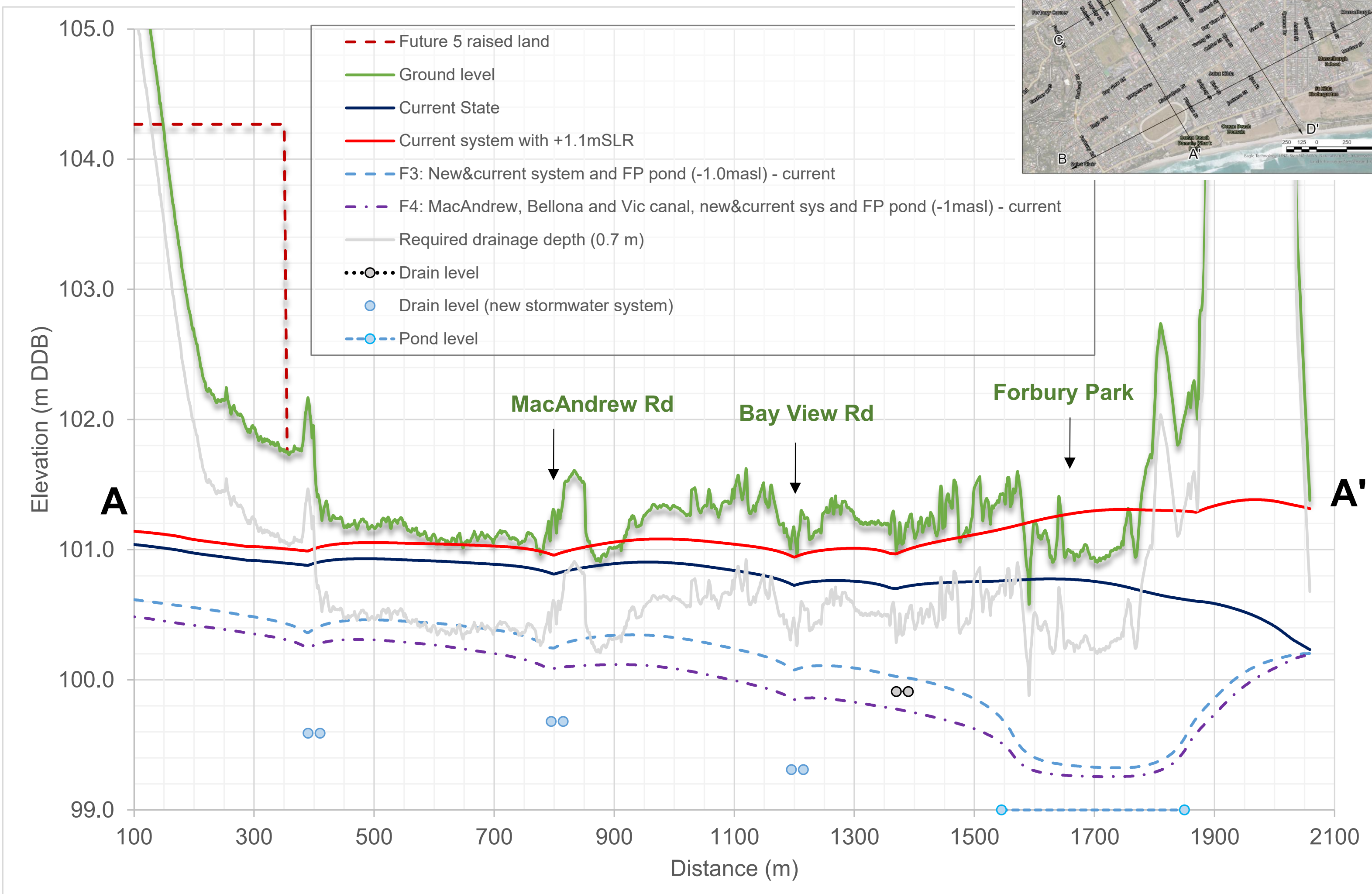
7


Future 5 + 1.1 m SLR
Cross section lines
Future 5 - raised land
Drainage features (current state)
Forbury Park Pond
New canals
Short term pipes
Future 5 (Future 4 & raised land) + 1.1 m SLR
<0 (susceptible to water ponding)
0 - 0.7 (exceed criteria)
0.7 - 1.5 (meets criteria)
>1.5 (low susceptibility)
A
A'
B
B'
C
C'
D
D'
Maryhill
Kensington
The Glen
Cargills Corner
South Dunedin
Forbury Corner
Saint Kilda
Musselburgh
Musselburgh Rise
Tainui
Chisholm Park
St Kilda Kindergarten
Ocean Beach Domain
Saint Clair
Hillside Rd
Macandrew Rd
Bay View Rd
Prince Albert Rd
Queens Dr
Portobello Rd
Portsmouth Dr
John Wilson Ocean Dr
Forbury Rd
Ings Ave
Allandale Rd
Eagle Technology
250 125 0 250 500 750 1,000
Meters
N

8

Section A-A" (current)





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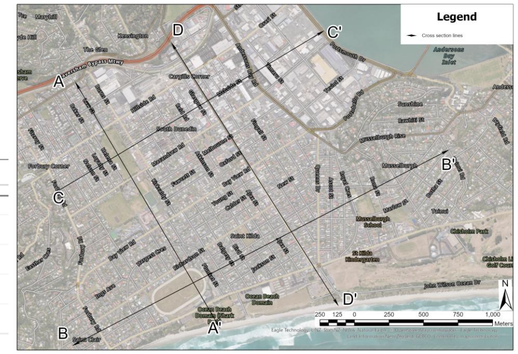

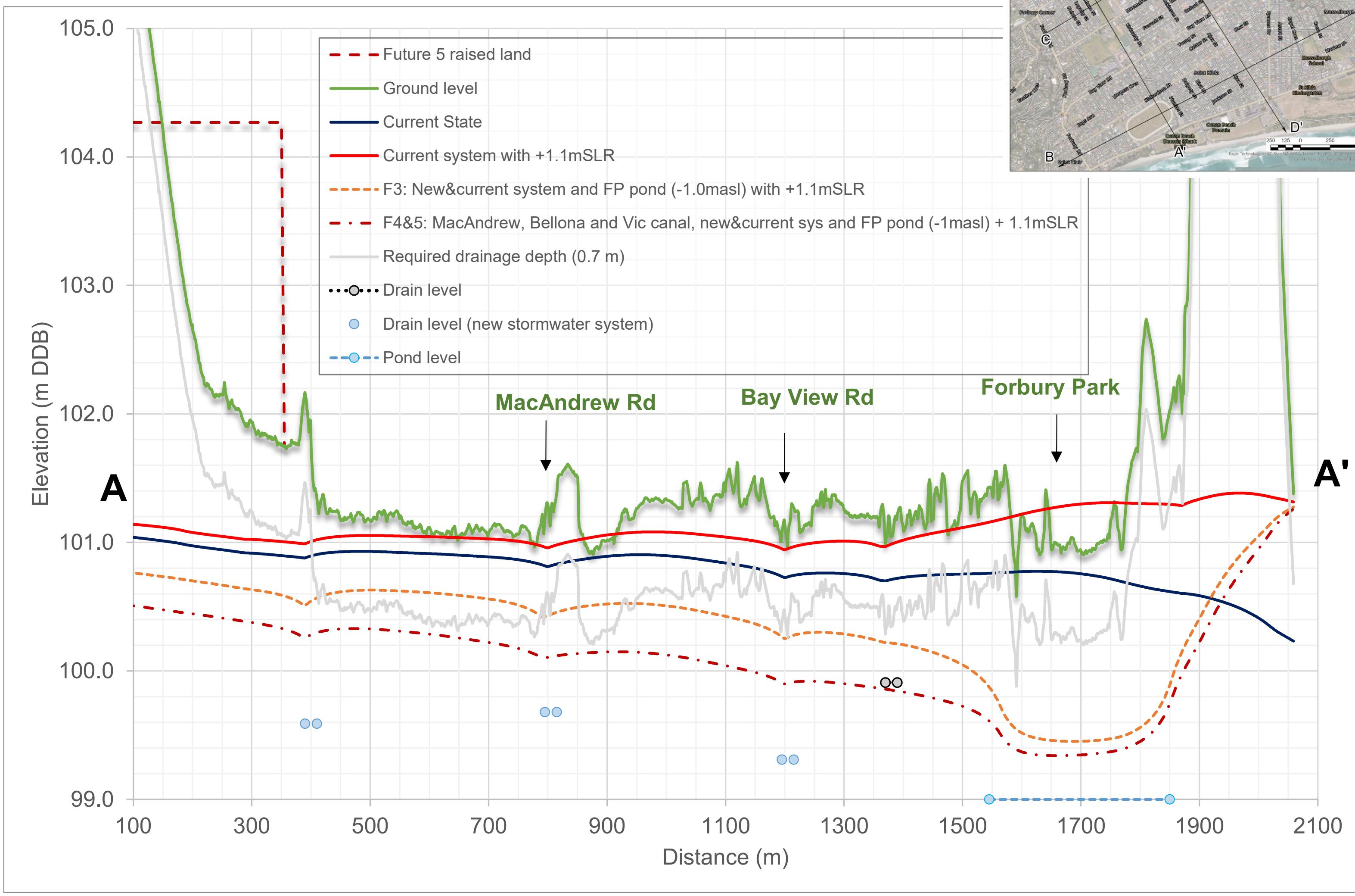

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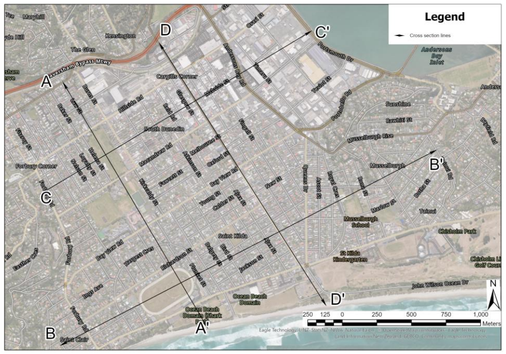

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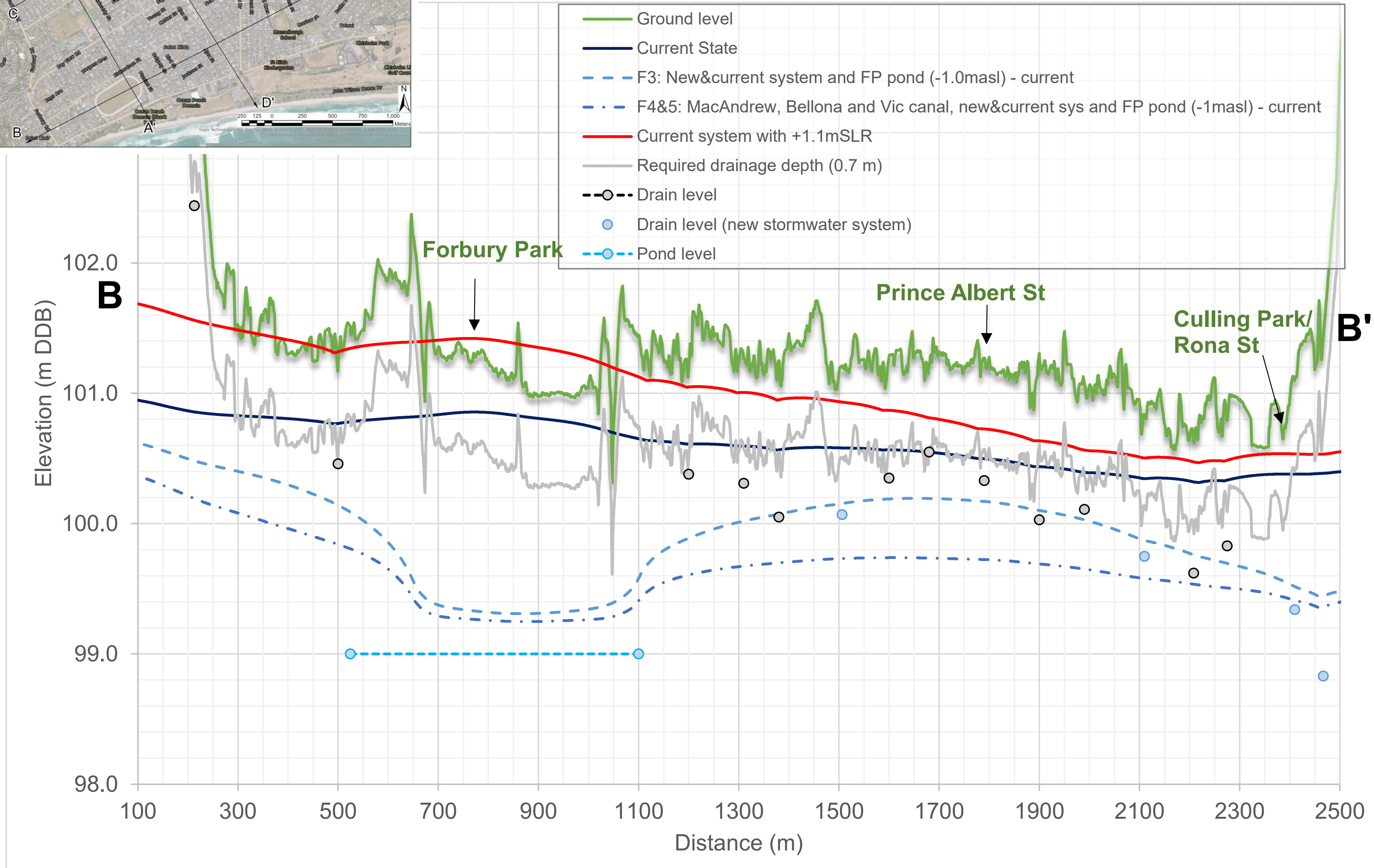

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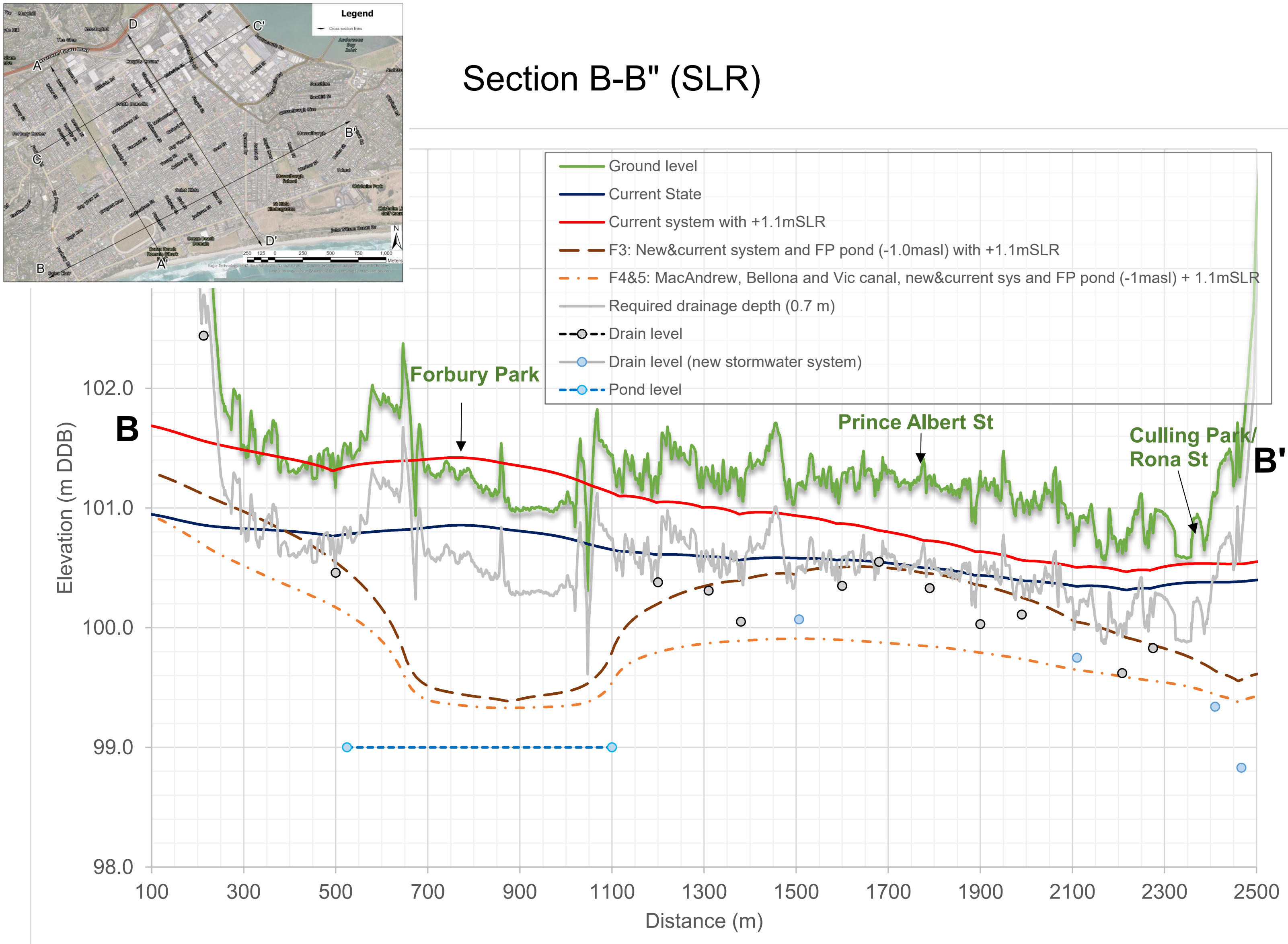

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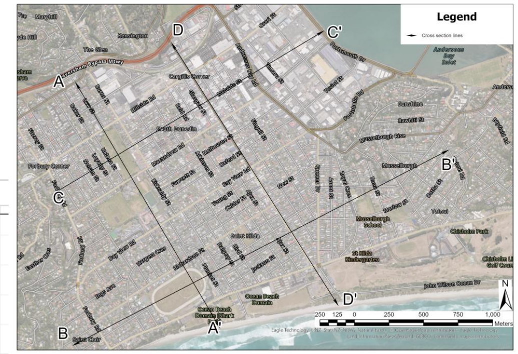

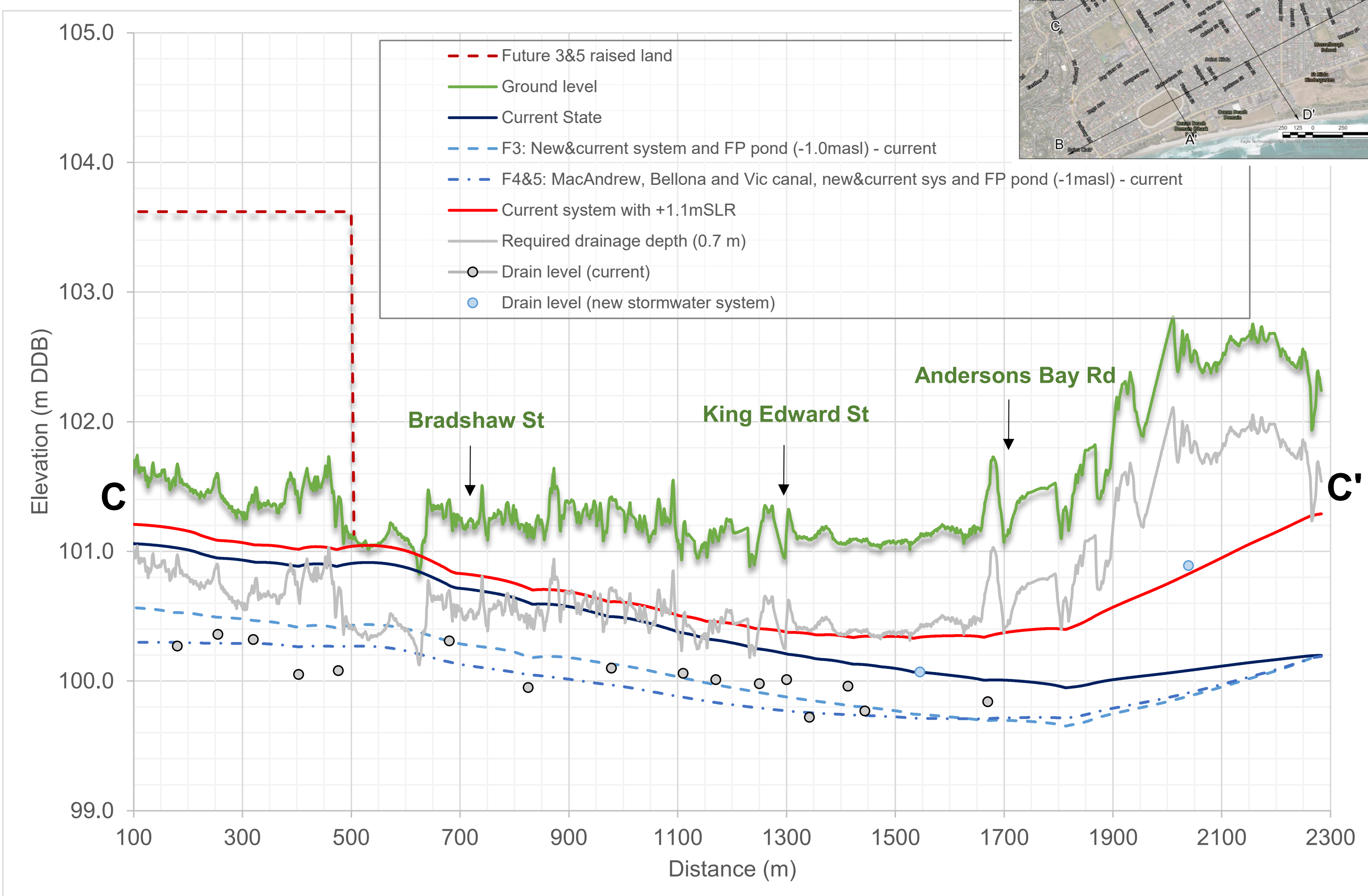

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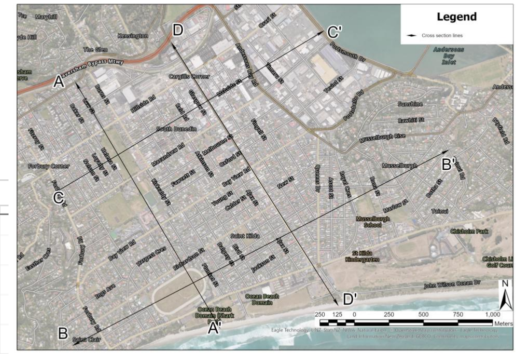

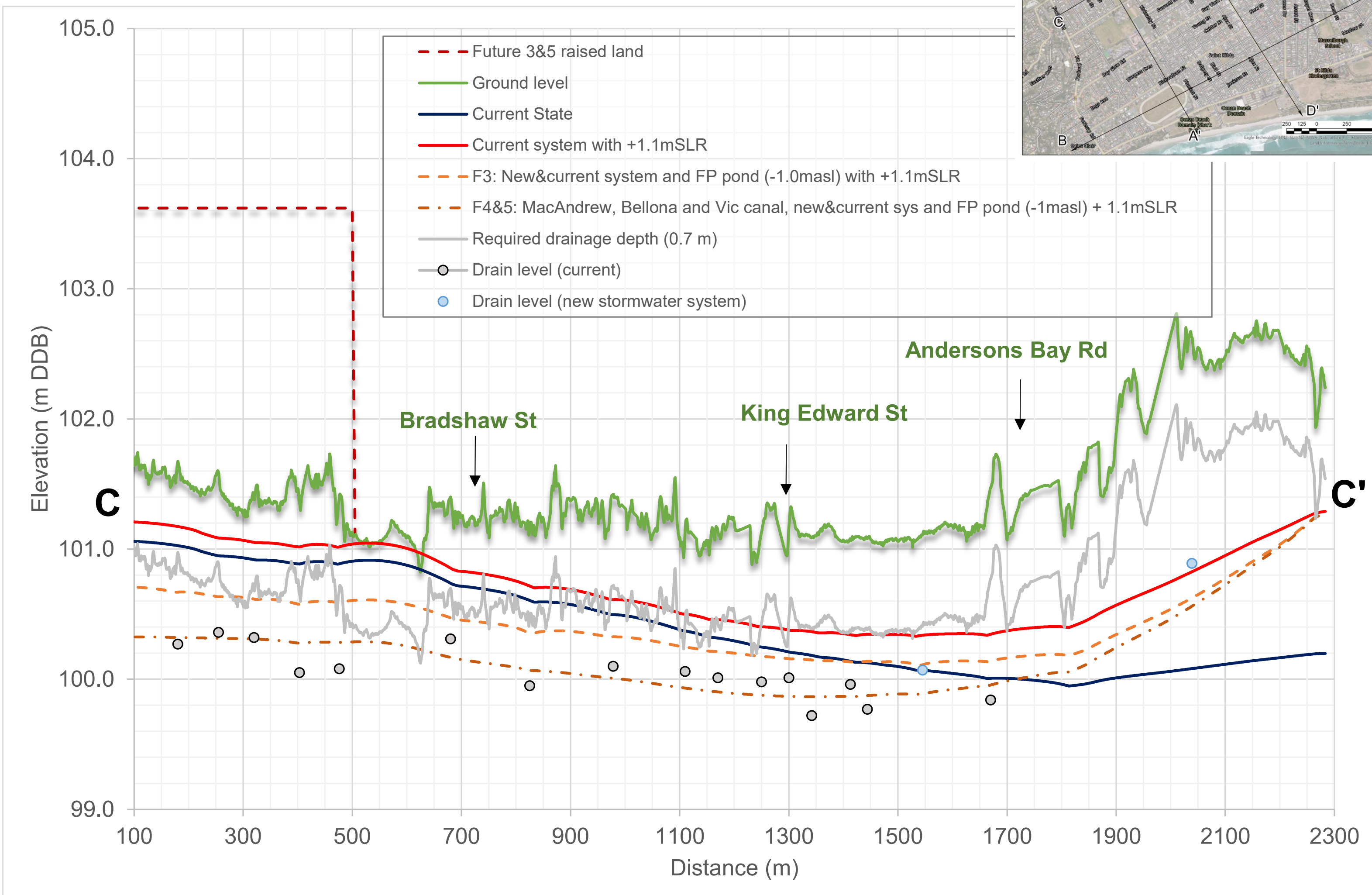

14

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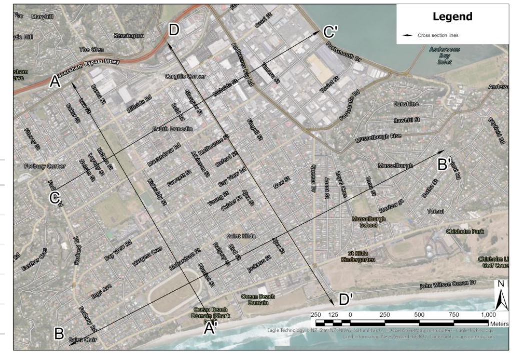

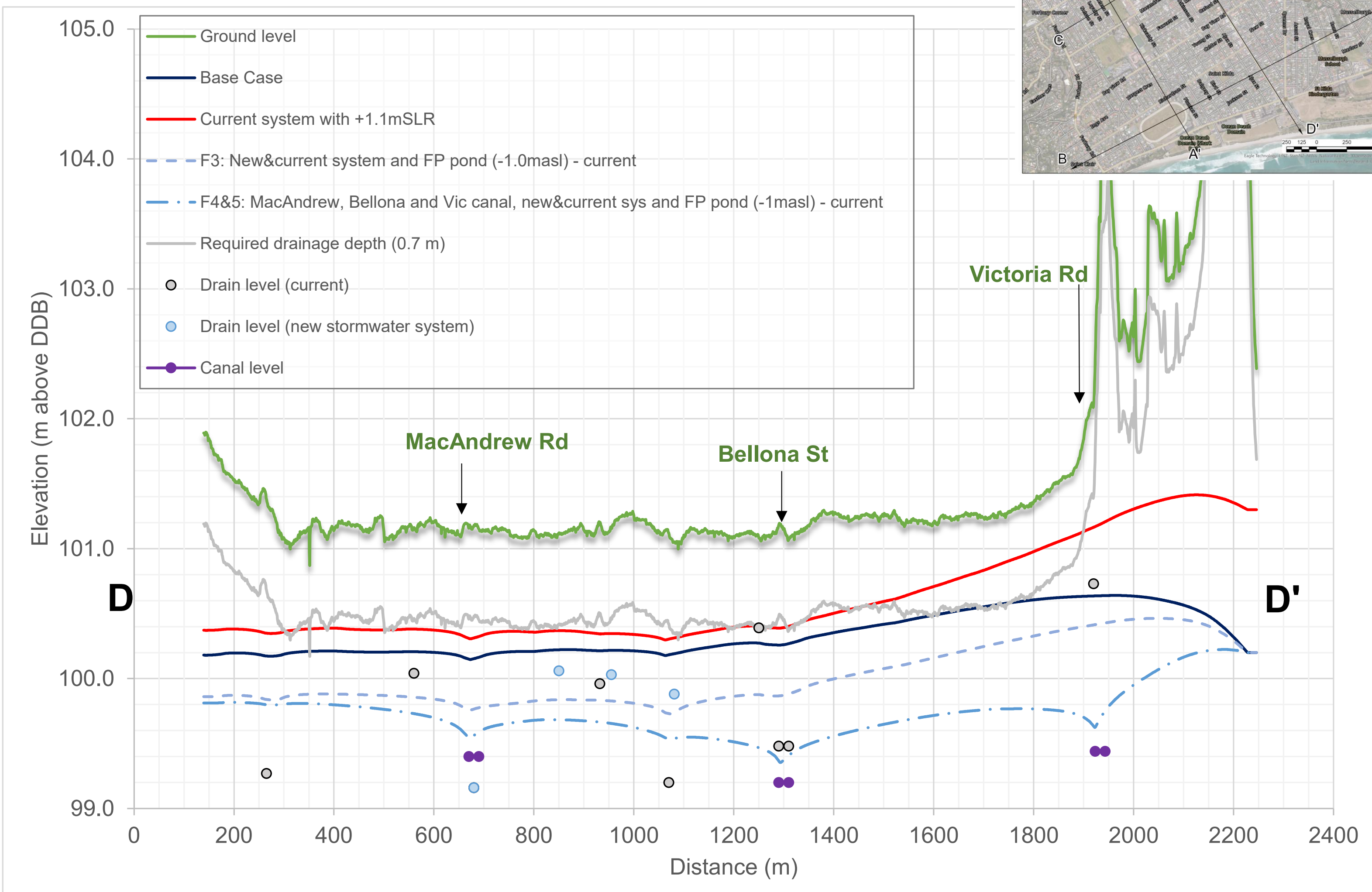

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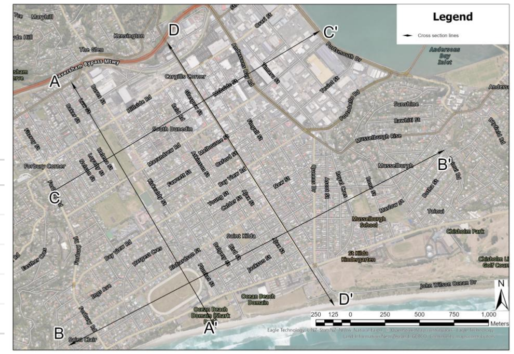

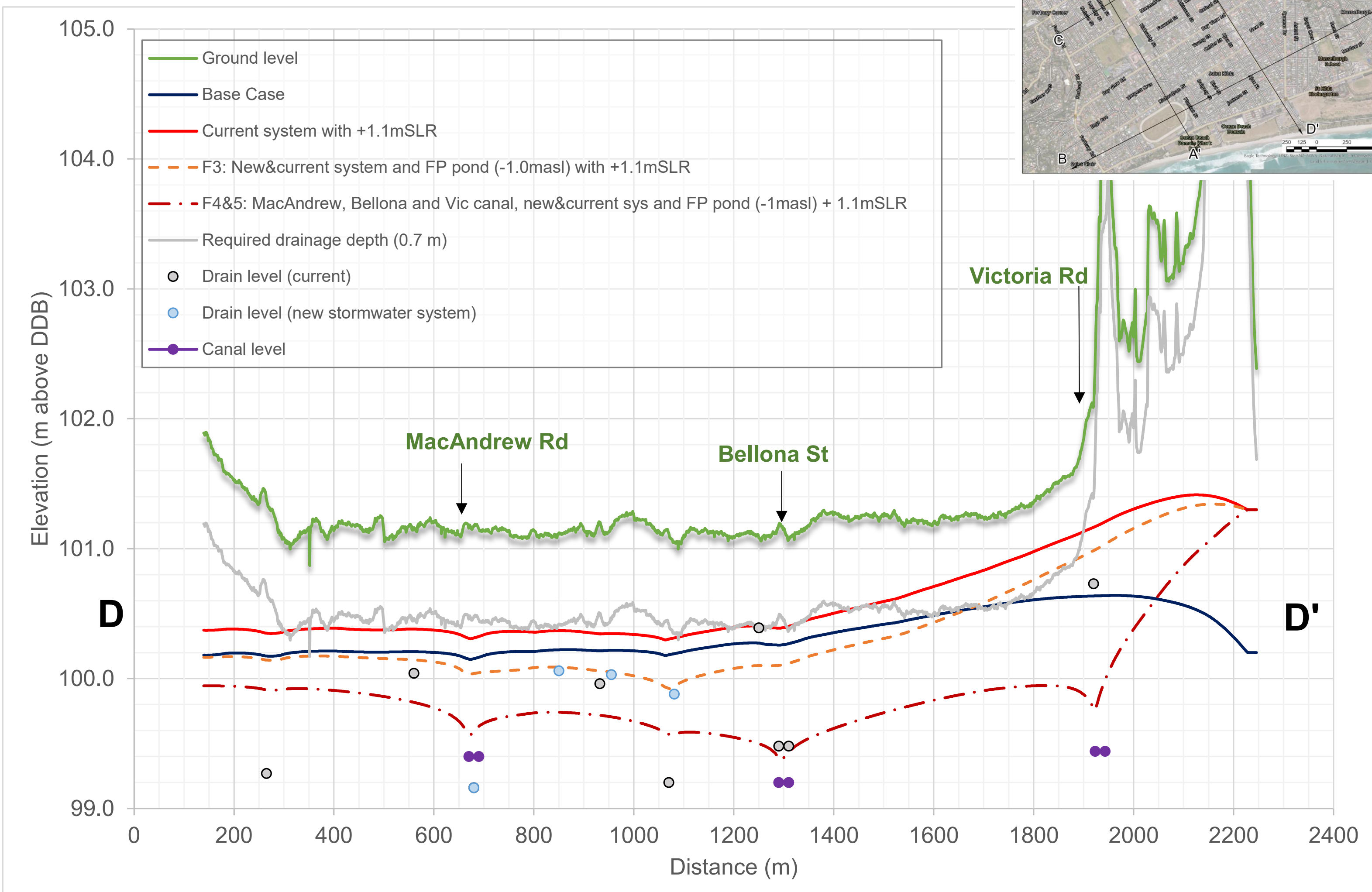

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SOUTH DUNEDIN FUTURE

SHORTLIST ECONOMIC EVALUATION (REVISION 4.1)

May 2026

SOUTH DUNEDIN FUTURE

SHORTLIST ECONOMIC EVALUATION

REV	DATE	DETAILS
1.0	15/12/25	For Review
2.0	20/02/26	Post Peer Review & Client Comments received and report amended Additional changes to economic modelling to represent Annual Average Damages not the explicit 1% AEP damages and damages avoided.
2.1	25/02/26	Section 2.2 on Discount Rate amended to reflect economic model (as V1). Minor text improvements to - Sections 3.2.6,.3.3, 4, 8.2.1 &8.2.3 - Tables 3-C, 8-E & 8-F
3.0	02/04/26	Further amendments post reviews with Council and Peer Review. - Revisions to BCR following on from further modelling (including changes to costs and modelled benefits. Discount Rate change to SOC from WACC. - Dwelling numbers reduced in line with address point information received – not individual building level costs) - Additional analysis re SRTP (Section 3). - Textual & language changes to support understanding. - Inclusion of coastal damages avoided approach within Core BCR for Medium & Long Term to properties only - Simplification of Assessment against Status Quo ONLY. Do Nothing removed. Modelling received for Status Quo modelling and analysed – Brings economic report into consistency with the other SDF outputs for this phase.
4.0	May 26	Minor consistency changes and typos resolved following further Client Review, alongside other deliverables.
4.1	May 26	Figures 4.1, 4.3 and 4.5 updated

Version 4.1	NAME	DATE	SIGNATURE
Prepared By	Liam Foster	21/05/2026	ON FILE for V4.0
Reviewed by	Quanita Ali	21/05/2026	
Approved by	Kevin Wood	21/05/2026	

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This report ('Report') has been prepared by WSP (via the Kia Rōpine group) exclusively for the South Dunedin Future Programme team (Dunedin City Council and Otago Regional Council) ('Client') in relation to the South Dunedin Future Programme – Short List Adaptation Approaches stage of the programme ('Purpose') and in accordance with the Agreement. The findings in this Report are based on and are subject to the assumptions specified in the Report, the Agreement and associated attachments, and Client Data supplied during the data request phase. WSP accepts no liability whatsoever for any use or reliance on this Report, in whole or in part, for any purpose other than the Purpose or for any use or reliance on this Report by any third party.

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This report is not intended to provide financial, investment, or legal advice. It should not be used as the sole basis for making financial or strategic decisions. The Client is encouraged to seek professional advice in these areas. Due to the nature and stage of the project, broad assumptions have been made to support costing of options. The status of this cost estimate represents at best a strategic stage. It presents a range of potential future states for South Dunedin for comparative uses ONLY. Cost estimates are exclusive of GST, project development, legal or marketing costs, escalation, operational costs/ downtime due to operations, removal of large / unforeseen ground objects, contaminated waste disposal or rebuild of existing properties in new location.

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APPENDICES

GLOSSARY

- AAD (Annual Average Damage) - A long-term annualised estimate of average flood related damages across multiple events and probabilities. AAD is the primary metric for quantifying benefits in the shortlist economic evaluation, replacing single event AEP damage estimates. The reduction in Expected Annual Damage (AAD) delivered by each proposed future relative to the Status Quo baseline. The Status Quo which incorporates current LTP stormwater investment and, from the medium term onwards, coastal inundation exposure is the sole reference comparator in this evaluation. A standalone 'Do Nothing' scenario was included in earlier phases of the programme but has been removed from this shortlist analysis to align with the framing used across all other SDF shortlist outputs. All benefit estimates are therefore measured as damages avoided relative to the Status Quo trajectory, not against a hypothetical zero-investment baseline.
- AEP (Annual Exceedance Probability) -The probability that a flood event of a given magnitude (e.g., 10%, 2%, 1% AEP) will occur in any year. AEP values are used only as modelling inputs, not as the basis for benefit quantification.
- Avoided Damages / Avoided AAD - The difference between the Expected Annual Damage under the Status Quo scenario and the Expected Annual Damage for one of the three future scenarios (Futures 3 – 5). This forms the core economic benefit used in the evaluation.
- BCR (Benefit–Cost Ratio) - The ratio of the present value of benefits to the present value of costs. In the revised framework, headline BCRs reflect Base Case Benefits only (AAD based avoided damages).
- Efficacy modelling – Represents the outputs from the pluvial hydraulic modelling exercise undertaken to support the assessment of the efficacy of the proposed futures against the status quo (also known as stormwater modelling).
- Futures 3, 4, 5 (Proposed Adaptation Futures) - The three futures selected following technical, economic and community assessment. They differ in adaptation strategy, staging, infrastructure mix, and extent of land use change.
- Hedonic Uplift - Increases in land or property values arising from reduced hazard exposure or improved amenity. Treated as Supplementary Benefits, not included in the Core BCR, due to double counting risks.
- LoS (Level of Service) Proxy - A monetised placeholder representing enhanced service or amenity levels (often set as a percentage of CAPEX). Considered a noncore benefit because of uncertain empirical basis and overlap with avoided damages.
- Residual Risk - The remaining level of flood risk after adaptation interventions are implemented, informed by the residual risk modelling inputs memo.
- Status Quo - An intervention scenario based on current LTP funding, used for comparison where proposed short-term and medium-term interventions are undertaken (as included in current Long-Term Plan) – with the remaining area subject to only essential renewals and limited maintenance. This represents the base against which other futures are compared.
- Supplementary Benefits - Benefits such as hedonic uplift (including LoS) that are presented separately to maintain defensibility and avoid inflating BCRs.

KEY FINDINGS

Dunedin City Council (DCC) has engaged Kia Rōpine (KR) to provide an economic evaluation of the short list of possible futures for South Dunedin, as part of the latest stage of adaptation planning work under the South Dunedin Future Programme.

SCOPE

This economic evaluation exists to answer a specific question: Does the evidence support investment in adaptation, and if so, which adaptation future delivers the most value for the public dollar? The answer requires holding two things in view simultaneously: what it will cost the community to act, and what it will cost the community not to.

The evaluation covers 100 years from 2027. This is not an arbitrary timeframe. Infrastructure investment of the kind contemplated in each future has a design life measured in decades. The consequences of under-investing in the past and continuing this through the 2020s will be felt in damage, in lost property value, in deteriorating liveability well into the 2070s and beyond. A 100-year lens is the minimum needed to capture the full arc of both costs and benefits.

Four futures are assessed: the Status Quo, which captures current planned LTP stormwater investments and maintains current assets without major new adaptation; Future 3 (Protect); Future 4 (Restore); and Future 5 (Reshape).

All three adaptation futures are compared against the Status Quo, a scenario in which current proposed projects have been implemented. It is the reference against which avoided damages are calculated, and it represents the possible trajectory of accumulated harm, based on the existing urban form and approved stormwater infrastructure at time of drafting.

Future regeneration use of the land is subject to separate decision-making and investigation with Council and will be assessed separately.

APPROACH

The analysis adopts a societal perspective, sharing the impacts on both individuals and wider society, and it uses a 100-year timeframe. Standard cost-benefit assessment framework using generally accepted best practices outlined by The Treasury, the Commerce Commission and NZIER were used. A sensitivity test has been undertaken for the key variable, real discount rate, with the Benefit Cost Ratio (BCR) tested for a margin of error of ± 15%.

This report summarises the evaluation methodology, key assumptions and exclusions and results, with the following key inputs/outputs:

1. Spatial boundaries and geographical information systems (GIS) approaches for assessing each proposed future.
2. Monetised whole-of-life costs for each proposed future over the return period.
3. Monetised benefits for each proposed future over the return period.
4. BCR for each proposed future.

CORE LOGIC

The primary metric used throughout this evaluation is Annual Average Damage (AAD). AAD is the annualised expected cost of modelled pluvial flood and a geospatial assessment of coastal inundation damage across all probability events, the 10%, 2%, and 1% Annual Exceedance Probability rainfall events weighted by their likelihood. Put simply, it represents what the community would pay each year, on average, if it were fully insured against all flood events at their expected frequency and severity.

AVOIDED DAMAGES – THE CORE BENEFIT

The primary economic benefit of each future is the reduction in expected annual pluvial & coastal flood losses relative to the Status Quo. The calculation is straightforward in concept: avoided damage equals the difference between what flood events would cost without adaptation and what they cost with it.

Avoided property damage is the largest single component, representing approximately 80% of total core benefits across all the three proposed futures (using pluvial flood modelling outputs and DCC's Flood Damage Assessment approach). The remainder comprises avoided injury and fatality costs (approximately 14%), avoided emergency response and recovery costs, and other co-benefits, including trauma, income loss from displacement, and environmental costs.

The dominance of property damage in the benefit profile reflects the density of the exposed building stock, concentrated population and the severity of the projected damage trajectory.

TOTAL BENEFITS OVER TIME

Benefits grow over time as the Status Quo damage trajectory steepens. In the short term, all three adaptation futures deliver identical benefit profiles because the pluvial flood efficacy modelling assumes equivalent near-term reductions in flood risk. The differentiation occurs in the medium and long terms as each future's physical characteristics interact with changing hazard conditions.

Table 1.1 - Total core benefits by future and period (NPV $m, 6% discount rate)

Time Period	Future 3 Protect	Future 4 Restore	Future 5 Reshape
Short-term (0 – 25 years)	$452	$457	$450
Medium-term (26 – 50 years)	$372	$381	$378
Long-term (51 – 100 years)	$511	$514	$507
Total - whole of life	$1,335	$1,351	$1,336

It may seem counterintuitive that the long-term epoch (51–100 years) accounts for such a large share of total benefits despite discounting, which reduces the present value of future cash flows.

Status Quo damage trajectory steepens dramatically over the assessment period. Pluvial & coastal flood AAD rise from ***$11m*** today to ***$212m*** by 2127, indicating that the current proposed initatives will continue to be challenged by growing levels of exposure over the 100 years. The benefits of adaptation grow in proportion to the damages avoided. The damages are largest in the period when climate impacts are most severe.

This timing structure is consistent with international practice in climate adaptation cost-benefit analysis. It is not a reason to delay investment, quite the opposite. The infrastructure that delivers those long-term benefits must be planned and built in the short- to medium-term. Early action captures the full benefit profile and enables infrastructure catch up to occur; delay truncates it.

As hazards intensify, the cost of inaction grows rapidly, meaning the relative benefit of early and sustained adaptation becomes increasingly significant over the medium and long terms, as shown in Figure 1.1 below.

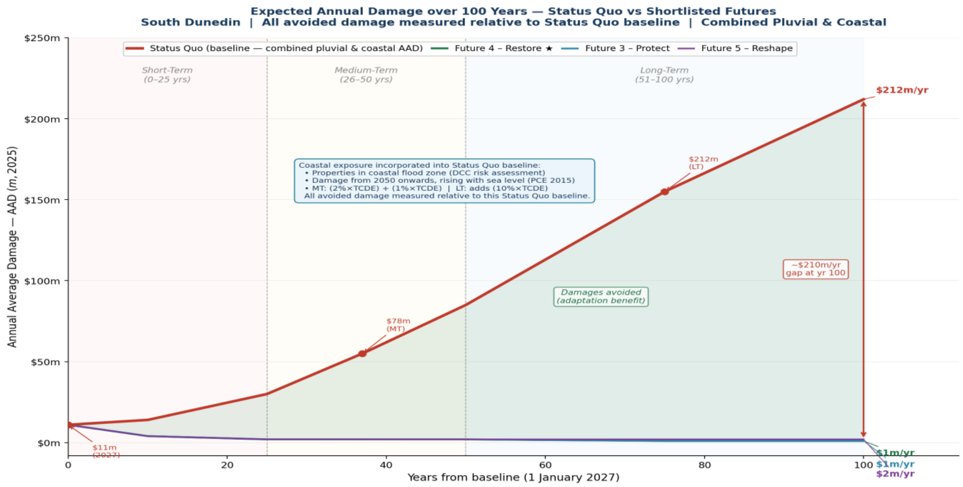

Figure 1-1 -Expected Annual Damage over 100 Years: Status Quo vs Shortlisted Futures.

The analysis distinguishes between core avoided loss benefits and supplementary benefits that reflect a broader level of service gain. This separation supports a transparent, defendable appraisal. The core case demonstrates the minimum likely return from risk reduction, while the supplementary case illustrates the broader opportunities that may enhance the long-term performance of the preferred future. This provides decision-makers with a clear and robust understanding of the economic rationale before considering Benefit–Cost Ratios.

WHAT EACH FUTURE COSTS?

Benefits do not come free. Each adaptation future requires substantial upfront investment in infrastructure, property acquisition and change in use or repurpose, as well as ongoing maintenance and operational expenditure. Understanding the likely cost structure for each future is essential for assessing value for money.

Table 1.2 – Total Costs by future – whole of life (2025 NPV $m, 6% discount rate)

Core component	Status Quo	Future 3 Protect	Future 4 Restore	Future 5 Reshape
CAPEX Investment	$290	$1,220	$724	$1,287
Repurposed Land Activities	$4	$433	$447	$545
Land & Property Acquisition	$72	$343	$338	$519
Capital Maintenance (cyclical)	$15	$33	$39	$31
Operational Expenditure (OPEX)	$31	$70	$81	$66
Total Costs	$411	$2,098	$1,629	$2,448

Future 4 has the lowest total cost of the three possible futures, with an NPV of $1,629 m over the whole of life. Its cost advantage over Future 3 ($2,098m) and Future 5 ($2,48m) reflects a more moderate infrastructure CAPEX programme of $724m, compared to $1,220m and $1,287m, respectively.

Future 4's blue-green approach relies more heavily on waterway restoration and natural flood storage, which are less capital-intensive than large-scale land-raising or pumping infrastructure.

The Status Quo has the lowest absolute cost ($411m) but is shown to not keep pace with the projected challenges facing South Dunedin, leaving flood risk exposure, to pluvial and coastal sources, privately borne with consequential cascading impacts. Furthermore, the groundwater assessment identified 838 properties, whose use is likely to be compromised over the next 100 years, as they become exposed to emergent groundwater.

CORE BENEFIT COST RATIO

In addition to the pluvial and coastal flood AAD driven avoided damages, co-benefits are calculated that are quantitatively assessed and directly linked. The Core BCR (at the central 6% discount rate) ranges from 0.55 (Future 5) to 0.83 (Future 4) across the proposed futures. Under the Social Rate of Time Preference scenario, this midpoint range improves (2.85 – 3.83), with Future 4 exceeding the benefit-cost breakeven threshold. It is presented using a range to avoid overstating certainty. This range is different to the *0.1* – *1.0* in the Long List (See Section 8 for details).

Table 1.3 – Core BCR – whole of life (2025 NPV $m, 6% discount rate)

Future	Benefits	Costs	Core BCR (midpoint)	BCR range (±15%)	Rank
Future 3 - Protect	$1,335	$2,098	0.64	0.54 – 0.75	2
Future 4 - Restore	$1,351	$1,629	0.83 ★	0.71 – 0.98	1
Future 5 - Reshape	$1,336	$2,448	0.55	0.46 – 0.64	3

The Core BCR uses the most directly evidenced, hazard-linked benefit streams: avoided property damage, avoided injury and fatality costs, avoided emergency response and recovery costs, avoided trauma, avoided income loss from displacement, and avoided environmental costs.

It excludes supplementary benefits such as hedonic value uplift and broader ecosystem gains, which are real but carry more uncertainty. This separation is deliberate; it ensures the core case rests on the most defendable evidence. Additional benefits can be transparently presented as upside.

Future 4 is the highest-performing future on the core BCR at 0.83, and is the clear first-ranked future across all primary BCR metrics. Future 3 ranks second at 0.64 and Future 5 third with 0.55.

The relatively low BCR for Future 5 ($2.45b in costs against $1.34b in core benefits) reflects its high capital intensity, as it is the most expensive of the three adaptation futures without a proportionate uplift in core avoided damages. Future 5's cost includes the largest property and land acquisition programmes ($545m and $519m, respectively), which do not directly generate avoided damages but are necessary to enable land-use change.

The whole-of-life BCR is a useful single summary figure. Still, it can obscure important structural features of climate adaptation economics. That costs are typically frontloaded, while benefits are backloaded. The epoch-level BCRs make this visible.

Table 1.4 – BCR by epoch – whole of life (6% discount rate).

Epoch	Future 3 Protect	Future 4 Restore	Future 5 Reshape
Short-term (0 – 25 years)	0.28	0.36	0.23
Medium-term (26 – 50 years)	0.82	1.33	0.80
Long-term (51 – 100 years)	10.61 ★	8.86 ★	14.58★
Core BCR (midpoint)	0.64	0.83 ★	0.55

Long-term BCRs of between *8.9* and *14.6* across Futures 3 - 5 are striking. They are not a modelling anomaly, and they should not be read as suggesting that the economics only work if you wait until the long term. Rather, they reflect a straightforward structural reality.

In the long term, most capital costs have already been incurred, and the infrastructure is delivering risk reduction against a damage trajectory that has become very severe. The marginal cost in the long term is primarily maintenance and operations; the marginal benefit is avoiding property AAD events alone that could occur regularly.

The practical implication is this: the infrastructure that generates those long-term BCRs must be built in the short- to medium-term, when BCRs are lower and uncertainty is higher. Delay does not improve the economics; it defers the benefit while the damage trajectory continues to steepen.

The Long-Term (51 – 100 year) BCRs are notably stronger than the whole-of-life BCRs. This reflects the timing profile of the futures: most capital costs are incurred in the Short- and Medium-Term, while a large share of risk-reduction benefits accrues later as climate hazards intensify. When assessed on a standalone basis, the long-term period shows high value for money because relatively modest incremental costs are used to avoid very large future damages.

The whole-of-life BCR combines all three epochs and is therefore influenced by (i) the concentration of costs in the early decades and (ii) the discounting of distant benefits. This pattern is consistent with international practice in climate-adaptation cost-benefit analysis, where upfront capital investment is compared with benefits that grow over time as hazards intensify.

Higher Long-Term BCRs relative to whole-of-life BCRs mainly reflect timing and discounting effects, rather than a modelling anomaly.

SUPPLEMENTARY EXTENDED BENEFITS

With supplementary benefits included, the BCR ranges from 0.68 (Future 5) to 0.94 (Future 4) at the 6% central rate. These supplementary BCRs are presented for completeness and carry a double-counting risk that is disclosed in Section 5 of this report.

UNQUANTIFIED BENEFITS

Several benefits were not monetised (but could be included in future analyses). All else being equal, these could increase the BCR. The unquantified benefits include:

- Avoided damages to non-council utilities (other than through the CV of each property).
- Reduced congestion and increased accessibility through urban areas.
- Insurance coverage and avoided insurance withdrawal.
- Regeneration benefits associated with urban development uplift of the study area.

NEXT STEPS

A further CBA will be developed for the next phase of the project, Preferred Pathway in 2026, incorporating refined assumptions, broader benefit categories and more detailed modelling. That CBA should result in a narrower BCR range because of higher level of certainty about inputs.

It is worth highlighting, currently, that this economic assessment is not in place to support future business case development, in relation to the implementation of the programme. This would follow on from the current planned activities as part of the South Dunedin Future programme.

1 PROJECT BACKGROUND

1.1 SCOPE

Kia Rōpine, as part of the delivery of the wider South Dunedin Future programme, has undertaken an economic evaluation of the possible futures for South Dunedin. The economic evaluation has been prepared following a standard cost-benefit assessment framework and the generally accepted best practices advocated by The Treasury, the Commerce Commission and NZIER.

The scope of this analysis/phase was confined to the proposed futures work, described in the *Three proposed adaptation futures for South Dunedin", date March 2026.*

The economic evaluation has assessed and compared the expected whole-of-life costs and benefits of each proposed future, relative to the Status Quo condition – where proposed stormwater infrastructure investment, identified within current DCC plans has been implemented and are supporting the existing community. The key driver of this economic evaluation is to provide comparable evidence to DCC and the stakeholders to agree on the most preferred future.

1.2 APPROACH

Our approach was shaped by the relatively short time available. We took a social perspective where possible, including the costs and benefits to individuals and wider society. The work compares the Status Quo future (representing current infrastructure interventions under assessment) to three future scenarios – the Three (3) Proposed Adaptation Futures for South Dunedin (referred to *Proposed Futures* for the rest of the document). The following steps were undertaken:

- Reviewing the CBA done for the Seven (7) Potential Adaptation Futures and Microbusiness Cases (referred to as *Long List* for the rest of the document) and its supporting models.
- Reviewing existing literature about CBAs of pluvial flood protection systems to identify typical costs and benefits, and additional elements that could augment the Long List phase.
- Recreating the CBA, with additional costs and benefits, including further refined flood modelling outputs of the Status Quo and Proposed Futures on flood exposure and depths.
- Assessing model outputs through a sensitivity analysis, accounting for a margin of error, and identifying key variables that have the biggest impact on the assessed benefit-cost ratio (BCR).
- Provide comparable BCR ranges of the proposed futures to support the next phase of the South Dunedin programme – the Preferred Pathway and Adaptation Masterplan development (referred to as *Preferred Pathway* for the rest of the document).

1.3 INTERPRETING THE RESULTS

The BCR is calculated as the net present value of all the monetised benefits divided by the net present value of all the monetised costs.

A BCR of 1 is where the net present value of the monetised benefits equals the monetised costs. If the BCR is less than 1, the costs outweigh the benefits (and vice versa).

The BCR in this report does not include all the costs and benefits.

It includes only those that could be quantified and monetised at this stage. There are other costs and benefits that are generally considered as part of any investment decision. This is detailed in Sections 5 and 6, with the expected implication to the BCR outlined. This will be captured under the parallel process of undertaking a multi-criteria assessment.

1.4 DATA SOURCES

The BCR is based on information that is subject to change, representing three Proposed Adaptation Futures for South Dunedin to address future climate conditions. This will be developed further at the subsequent Preferred Pathway stage.

Much of the information utilised in this analysis was prepared during the development of both the Long and Short-Listing phases and is at a level of detail necessary to assess the overall viability of the futures and their potential for success. Alternative infrastructure arrangements are feasible and would achieve different outcomes, both in terms of the costs and benefits resulting.

We relied on outputs from other models.

As identified within the report, the avoided property damage is the biggest monetised benefit in our analysis. To estimate the value of this benefit, we relied on outputs from:

- DCC provided stormwater models for the study area – taken from recent modelling activities for the Integrated Catchment Modelling Programme. These were updated for the four futures.
- DCC's Flood Damage Assessment approach0F[1] was used to estimate the cost of the flood damage to buildings / properties.
- DCC provided coastal mapping outputs to support the identification of properties exposed to likely coastal flooding.
- Other key monetised benefits, such as avoided fatality & injury, avoided emergency services, and gains in level of service, are highly correlated with the outputs listed above[2].
- Kia Rōpine identified tactical interventions for each of the futures (see modelling efficacy report for details of these) across three-time epochs (Short-, Medium- and Long Term).

1.5 OUTPUTS

This report describes the modelling methodology, including a clear documentation of the assumptions made and their sources. The key inputs/outputs from this project are:

- Spatial boundaries and geographical information systems (GIS) analysis of each option of each proposed future.
- Monetised whole-of-life costs for each proposed future over the return period.
- Monetised benefits for each proposed future over the return period.
- Benefit-Cost ratio (BCR) for each proposed future.

[1] DCC Flood Risk Assessment Technical Note (February 2025), produced by Stantec as part of the Integrated Catchment Modelling Programme

[2] Note on model outputs: The quantitative results presented in this report are derived from the economic model (version as of 31 March 2026). Tables in the report body represent verified outputs from that model as of the sign-off date. The model is Excel-based, and results are presented as confirmed static values; they are not live-linked. Any subsequent model updates would require corresponding amendments to the report.

2 GENERAL ASSUMPTIONS

This section outlines the general assumptions adopted within the economic evaluation. Other scenario-specific assumptions are set out in the following sections of the report.

2.1 ASSESSMENT TIMEFRAME

Based on a similar study (Auckland Council, 2025[3]), it was found that there is different domestic and international guidance on determining the timeframe for social investment proposals. The UK's flood appraisal guidance recommends a default 100-year timeframe[4]. The US FEMA Guidance[5] links timeframe to a project's useful life (35 – 100 years for major infrastructure like dams / levees).

From the above, shorter timeframes (e.g. 50 years or less) are likely to miss significant future damage avoidance and climate change impacts, understating benefits, whereas a 101+ year timeframe introduces excessive uncertainty beyond long-term planning capability, such that climate resilience projects could overstate benefits from the accumulation of future gains.

Through a process of elimination, an assessment timeframe of 100 years appeared reasonable as it adequately captures the long-term benefits from the proposed adaptation investments for pluvial and coastal flood mitigations, to support the analysis of the future climate resilience investment.

The economic evaluation is undertaken with a **baseline date of 1 January 2027** with a 100-year timeframe, which is segmented into three time periods of short term (0 – 25 years from baseline), medium term (26 - 50 years from baseline), and long term (51 - 100 years from baseline). All costs and benefits are assumed to incur halfway through the fiscal year. All values are presented in Net Present Value (NPV) terms.

2.2 DISCOUNT RATE

Headline Benefit–Cost Ratios in this report are calculated using a 6% discount rate derived from a weighted average of the Social Opportunity Cost of capital (SOC) and the Social Rate of Time Preference (SRTP), consistent with The Treasury's guidance on public sector discount rates for cost–benefit analysis.

The detailed derivation of the underlying parameters is provided in Appendix A for transparency. The approach ensures alignment with Treasury public sector appraisal practice while maintaining consistency with the project's economic modelling framework.

2.3 COST GROWTH

Generally accepted industry practices suggest that sufficient project cost growth should be accounted for to ensure rigorous and evidence-based investment proposals. The general expectation is increasing cost over time (inflation) to reflect rising material costs, consenting fee escalation, wage growth, etc.

[3] Auckland Council – Cost Benefit Analysis for Wairau Blue Green Network (2025)

[4] Flood and Coastal Erosion Risk Management appraisal guidance (2010). DEFRA/Environment Agency https://assets.publishing.service.gov.uk/media/613205c1d3bf7f05b9705049/The_full_technical_FCERM_appraisal_guidance.pdf, accessed October 2025.

[5] US FEMA (2009). BCA Reference Guide. https://www.fema.gov/sites/default/files/2020-04/fema_bca_reference-guide.pdf , accessed January 2026.

Following The Treasury's guidelines, the assumed short-term, medium-term, and long-term geometric annual cost escalation rate is 2.03%, 2.03% and 2.02%, respectively.

The economic evaluation has sensitivity tested the assumed cost growths under the discount rate sensitivity assessment, with cost growths embedded in the development of the real SOCs and real SRTPs following the Fisher equation, consistent with The Treasury's public sector cost benefit analysis guidance.

2.4 ANNUAL EXCEEDANCE PROBABILITY

Annual Exceedance Probability (AEP) is commonly employed under climate resilience proposals to reflect the likelihood that a specific magnitude of flood will occur or be exceeded in any single year.

To support the economic assessments for benefits calculations relating to fatality, injury and trauma damages, we have used an AEP of 2%, reflecting a flood event that occurs once every 50 years.

AEP values are used in this evaluation as modelling inputs to derive Annual Average Damage (AAD) estimates; they are not used directly as the basis for benefit quantification.

The AAD metric integrates flood damages across three modelled event severities: the 10%, 2%, and 1% AEP rainfall events weighted by their annual probability of occurrence. This probability-weighted approach produces a single annualised damage figure that reflects the full range of likely flood events rather than a single worst-case scenario. It is consistent with The Treasury's guidance for cost-benefit analysis of public investment, which requires probability-weighted (expected-value) loss estimation[6]

For the purposes of injury, fatality, and trauma benefit calculations, which require a single representative event to estimate population exposure, a 2% AEP event (1-in-50-year flood) has been applied, representing a significant but realistic flood scenario consistent with the modelled efficacy outputs.

[6] The Treasury, 'Guide to Social Cost Benefit Analysis' (2015), p.23: 'Use expected values (probability-weighted outcomes) in preference to single-scenario estimates.'

3 STATUS QUO

3.1 BACKGROUND AND KEY ASSUMPTIONS

We describe the main assumptions and outputs from the Kia Rōpine flood-modelling[7] projections (known as the ***Efficacy modelling***). This Future approximates the current long-term plan thinking for investment in stormwater flood mitigation works (known as the no regret projects). These represent a series of pipe upgrades and new pumping infrastructure added to the current network.

Comparing the futures economically against this baseline is in line with the other assessments undertaken through the programme to determine the proposed futures. This scenario has an important role, given that we compare the alternative futures to it, to understand the potential benefits of the proposed South Dunedin Future investment.

3.1.1 FLOOD RISK – CURRENT PLANS

We have assumed that no further flood mitigation measures will be put in place, other than those currently included within the Status Quo modelling to manage the identified growing coastal, pluvial and groundwater flood exposure for the Status Quo future.

The proposals represent the reference point against which we test the impact of the alternative futures as damages-avoided benefit. ***If no investment is implemented, then the size of the avoided damages benefit would be larger than characterised***.

3.1.2 CLIMATE CHANGE

We assumed that pluvial flooding would become more intense over the 100-year timeframe (with core assumptions / inputs identified (efficacy modelling)). This increase is shown to result in higher levels of flooding, leading to more properties becoming damaged over time and more severe.

3.1.3 COASTAL PROTECTION

We have assumed that no additional coastal protection infrastructure will be added to the harbour edge to manage the future coastal inundation exposure as presented within the risk assessment. For the purposes of this assessment, we have assumed that the St Clair to St Kilda coastal margin remains in place, for the period of the analysis, to protect the low-lying South Dunedin area.

3.1.4 GROUNDWATER

We have assumed that no groundwater management systems are added to the urban fabric to manage the current and future groundwater exposure as presented within the risk assessment, over and above the role that the existing stormwater and wastewater networks play.

3.1.5 BUILDING STOCK

We have assumed no change or improvements to the existing buildings, so we miss items where:

- A property inside the study area is to be sub-divided, then more properties would be exposed to flood damage and benefits would be greater.

[7] Kia Rōpine (2025) – SDF Efficacy Modelling Report_Rev A_signed.pdf

- An existing property is to be upgraded/refurbished over time, then the avoided property damages would be greater than currently modelled, where benefits would be greater.
- Impacts become untenable for property owners (no longer useful) meaning reduced costs, other than the 838 properties[8] identified.

At this stage, we cannot meaningfully forecast changes to housing densities or property values and have not included this in the analysis.

3.1.6 FUTURE LAND USE

We assumed no change to the current pattern of land use through the period of analysis.

3.2 MODELLED IMPACTS – PLUVIAL FLOOD EXPOSURE

Pluvial flood risk is known to be driven by intense rainfall, overwhelming drainage systems. A trend expected to worsen under climate change. The numbers below relate to the total number of buildings, taken from GIS assessments that are flood affected. For the purposes of the economic assessment, duplicated buildings for each land parcel were removed, to avoid double-counting.

3.2.1 INCREASING LEVELS OF FLOOD AFFECTED BUILDINGS

The number of buildings experiencing water around 50% of the building perimeter, and above-floor flooding rises dramatically across all three modelled return periods for all buildings (area > 30m^2).

Table 3.1: All buildings (> 30m^2) - impacts with Status Quo (to nearest 100)

Criteria	Return Period (AEP)	Current Day	2127
Water around 50% of the building	10%	1,000	2,600
	2%	1,900	3,200*[9]
	1%	2,300	3,400
Above floor flooding	10%	600	1,800
	2%	1,200	2,400*[5]
	1%	1,500	2,600

This shift represents a tripling of internal flooding in frequent events and almost doubling in major events, turning today's episodic events into chronic, city-wide disruptions.

3.2.2 LARGE SCALE RESIDENTIAL AND COMMUNITY DISRUPTION

Residential buildings experience the greatest increase in impact:

Table 3.2: Residential buildings (> 30m^2) - impacts with Status Quo (to nearest 100)

Criteria	Return Period (AEP)	Current Day	2127
Above floor flooding	10%	500	1,500
	2%	1,100	2,000*[5]
	1%	1,400	2,300

[8] DCC (2025): South Dunedin Future – Residential Capacity Analysis Storymap

[9] Approximated based on relationship from other events – as no future state 2% AEP case modelling available.

Consequences include:

- Rising displacement and emergency sheltering demand
- Increased mould, dampness, and degradation of building quality
- Greater mental-health impacts, particularly in repeatedly flooded households (recurrent flooding is strongly associated with higher depression, anxiety, and PTSD rates – evidenced in population-level studies from the UK)

Schools, churches, and other community facilities also face growing internal flooding, undermining community cohesion, and recovery.

3.2.3 INTENSIFYING BUSINESS, INDUSTRIAL AND INFRASTRUCTURE LOSSES

Commercial and industrial properties experience sharp increases in above-floor exposure:

Table 3.3: Commercial / Industrial buildings (> 30m^2) - Pluvial flooding impacts (to nearest 10)

Criteria	Type	Current Day	2127
Above floor flooding for 1% AEP	Commercial	50	190
	Industrial	50	150

Implications include:

- Disruption of essential services and supply chains
- Higher cleanup and reinstatement costs
- Loss of trading days and reduced investor confidence

3.2.4 INCREASING EVENT DAMAGES.

The Status Quo represents an estimation of the implications/impacts of the current proposals not being able to keep pace with the myriad of flooding challenges (this work is not inclusive of groundwater flooding exposure – that would further increase the likely future damages). This represents an increasing liability now and into the future that is identified to be in the order of $1.45 billion in 2025 NPV costs to the region, when accounting for:

- Damage to properties (insured & uninsured) with AAD rising from $11m (2027) to $212m (2120).
- Fatality and Injury costs.
- Emergency Service Costs, Trauma costs amongst others.

The $1.45 billion NPV figure reflects modelled direct property and human costs only. When factoring in other potential costs that result from ongoing flood exposure, such as infrastructure repair, private interventions, and the estimated cost of insurance withdrawal (categories that are outside the current quantitative model but are expected to be material), a figure of more than $2 billion of damages is not unrealistic. Both figures are presented to bracket the range of likely inaction costs at a strategic level.

Table 3.4: Pluvial event damages for buildings per return period for the Status Quo Scenario (Base)

Building Level. Status Quo Pluvial Flood Damages ($m) 2025 QV	Return Period (AEP)			AAD
	10%	2%	1%	$m
Short Term (Present Day)	$60	$140	$200	$11
Medium Term	$290	$430[*5]	$540	$43[*5]
Long Term	$420	$540[*5]	$630	$60[*5]

Table 3.5: Combined Coastal and Pluvial event AAD ($m, 2025 QV)

Epochs	AAD
Short Term (Present Day)	$11
Medium Term	$78[*5]
Long Term	$212[*5]

3.2.5 INCREASING PRESSURE ON INSURANCE AFFORDABILITY/AVAILABILITY

As events occur more frequently and internal flooding escalates, insurance impacts become severe:

- Greater claims frequency and severity, mirroring multi-billion dollar claim patterns seen in recent NZ flooding events.
- Higher premiums, larger excesses, and more exclusions, especially for repeat losses and groundwater/seepage pathways.
- Heightened risk of insurance withdrawal or non-renewal in the most exposed pockets. (Groundwater/seepage is already commonly excluded / only partially covered across the motu).

This creates affordability challenges and threatens long-term mortgage viability.

3.2.6 ESCALATING INFRASTRUCTURE AND NETWORK FAILURES

With approximately 4,000 buildings exposed to flooding for a 2% AEP pluvial flood event, there are:

- Increasing numbers of road closures and access failures, with a total road area with over 300mm depth of stormwater increasing from 1.6ha (current day) to 16ha (2100 state) for the 10% AEP event, with the centre line of over 150 roads impacted in the future compared to twenty currently.
- Park areas with stormwater depths over 300mm, increasing from 0.5ha to 4ha, affecting useability for the 10% AEP event.
- More stormwater and wastewater network surcharges.
- Reduced emergency response mobility.
- Decreased community confidence in essential services.

Reviews of pluvial flooding events, underscore that even well-designed networks face substantial residual risk if there are no exceedance pathways or depression areas to temporarily store water. Without intervention, chronic implications could emerge in relation to the liveability of the area.

3.2.7 LONG-TERM DECLINE IN NEIGHBOURHOOD VIABILITY

Without adaptation:

- Flood-prone areas are shown to lose value relative to safer suburbs.
- Rental housing quality declines under repeated damp and deterioration.
- Community out-migration increases, particularly among families.
- Vulnerable populations are disproportionately affected.

Together, these trends drive entrenched inequities, rising public health burdens and declining urban and individual resilience.

3.3 MODELLED IMPACTS - GROUNDWATER

A quick review of the groundwater information shared through the Kia Rōpine report and GNS modelling has been undertaken sharing the implications of groundwater on properties (using the 'no intervention' modelling work).

Work undertaken by DCC[6], identifies that 838 dwellings are predicted to become vulnerable to emergent groundwater over the 100-year period, with 58 likely to become exposed by 2050, a further 103 through to 2075 and then a further 678 by 2120.

Over 2 hectares of roads across the study area are predicted to be vulnerable to emergent groundwater into the future, with an additional 15 hectares lying within the zones predicted to have groundwater within 0 to 0.7m bgl, taking the total to over 58.5 hectares. Additionally, more than four hectares of park are predicted to have emergent groundwater in the future compared to the current state of less than 1,000m².

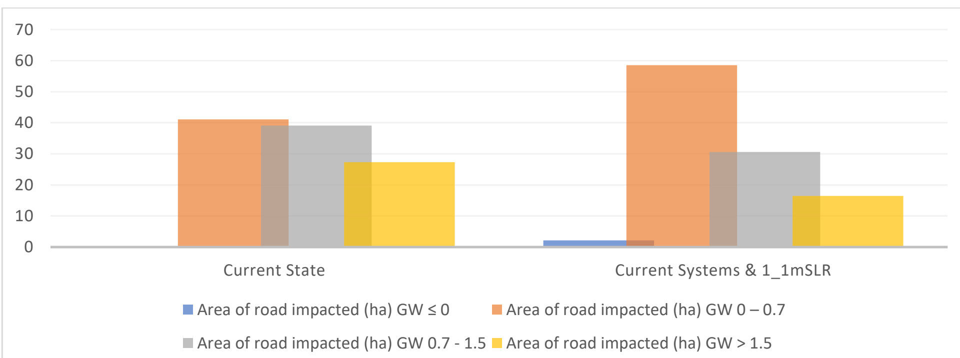

Figure 3-1 - Modelled outputs sharing current / future groundwater levels and road (km) impacted

3.4 CONCLUSION

A **Status Quo** future helps to reduce current exposure to pluvial flooding, when compared to no intervention. Pluvial flooding over time grows from a disruptive but recoverable hazard into a persistent, systemic, and increasingly unmanageable challenge, exacerbated by a growing groundwater impacts. By long-term horizon:

- Thousands more buildings are regularly affected.
- Internal flooding triples for frequent events.
- Insurance and infrastructure systems weaken under sustained pressure.
- Community wellbeing and economic performance decline.

In short, not investing in adaptation will likely lead to escalating annualised losses, reduced liveability, and diminishing strategic flexibility, making proactive adaptation far more cost-effective than continued inaction.

This evaluation uses the Status Quo as the sole reference baseline against which the performance of each proposed future is measured. A standalone 'Do Nothing' comparator was included in earlier phases of the SDF programme but has been removed from this shortlist assessment to ensure consistency with the other technical outputs produced for this phase, and to reflect the more precise Status Quo modelling now available. All damage estimates and avoided damage benefits presented from this point forward are measured relative to the Status Quo trajectory.

The combined pluvial and coastal AAD figures in Table 3.5 above ($78m mid-term; $212m long-term) reflect a material methodological development from earlier assessment phases. Coastal inundation exposure has been incorporated into the Status Quo damage trajectory. This is the primary driver of the increase from the pluvial-only figures shown in Table 3.4 ($43m and $60m respectively).

Coastal exposure methodology: Properties within the coastal flood zone were identified using DCC-provided coastal mapping outputs consistent with the SDF Risk Assessment. The 'bathtub' flood modelling available for the coastal zone likely overestimates flood depths; the approach adopted therefore, represents a conservative, early-phase approximation reviewed by the specialist team[3]. Damage was applied from 2050 onwards, consistent with Parliamentary Commissioner for the Environment (2015) sea level rise projections, with epoch-weighted annualisation as follows:

- Short Term (0–25 years): No coastal damage included, coastal inundation frequency below threshold for this epoch given current sea level projections.
- Medium Term (26–50 years): Annual average coastal damage = (2% × TCDE) + (1% × TCDE) where TCDE is the Total Coastal Damage Exposure for all affected properties.
- Long Term (51–100 years): Annual average coastal damage = (2% × TCDE) + (1% × TCDE) + (10% × TCDE), reflecting increasing inundation frequency with sea level rise.

Appendix B has further details of coastal damage approach (by building use type) and the TCDE.

3.5 POTENTIAL AREAS FOR FURTHER ANALYSIS

With a relatively short period to undertake the analysis, and knowledge of further stages requiring economic assessments., a more comprehensive CBA would support the development of the subsequent ***Preferred Pathway***. In relation to the Counterfactual analysis to date, we recommend:

- Confirming the assumptions for the Status Quo scenario into the future, including whether BAU activities proposed in the current Long-Term Plan would be put in place and built on, to understand the implications of these investments.
- Confirming assumptions about financial implications of increasing levels of flooding on the livability across the area, including implications on insurance availability and as to whether people would self-retreat and leave their homes.

- Undertaking further work on the likely flooding exposure related to coastal inundation to improve confidence in properties exposed to flooding across a 100-year time horizon. A more refined, depth-based assessment could be incorporated during subsequent phases.
- Confirming assumptions made as to whether additional properties, increasing levels of housing density, or changes to the value of existing commercial / industrial stock, could be modelled over the 100-year time, as opposed to assuming the status remains over the period.
- Undertaking further analysis as to the impacts on council infrastructure (over and above the roads and parks undertaken to date).
- Determining the need for capturing other costs, such as:
- Business interruption,
  - Service disruption (including the impacts of roads being closed on network use).
  - Implications for wider region from these changes (both positive and negative).
  - Insurance retreat and implications on asset values.

4 FUTURES DESCRIPTIONS

The GIS information provided by KR and DCC, has been spatially mapped for the Proposed Futures work, under each epoch, are presented in the subsections below.

4.1 FUTURE 3 – PROTECT

Protect manages stormwater and groundwater mainly via a network of pipes and pump stations to move water out of South Dunedin. Roads help to direct and hold water during intense rainfall and stormwater reserves or constructed wetlands provide even more storage when required.

To support this, Council would improve the seawall along Portsmouth Drive, and raise an area of Forbury Corner to expand the existing high ground and create intensified space for people to relocate to, away from areas of highest risk. To minimise the amount of land raising required, a new residential development is included in the Ocean Beach Domain area

Figure 4-1: Future 3 – Interventions over the three-time epochs

Figure 4-2: Future 3 key details

4.2 FUTURE 4 – RESTORE

Restore makes space for water by creating a network of open waterways and wetlands, supported by pipes, pumps, overland flow paths, and coastal protection. This future represents a balance between engineered and nature-based solutions and creates the opportunity for an extended town belt-type landscape, integrating South Dunedin into Dunedin's wider green network.

Some property acquisitions are required to create space for these interventions

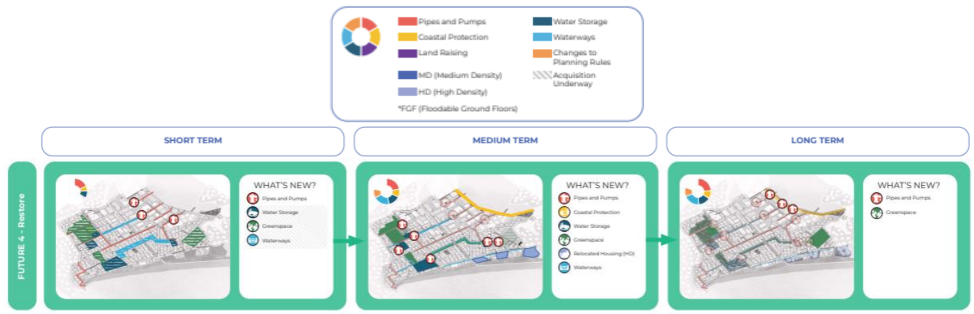

Figure 4-3: Future 4 – Interventions over the three-time epochs

Figure 4-4: Future 4 key details

4.3 FUTURE 5 – RESHAPE

Reshape focuses on creating space for water and people through a combination of open waterways, green infrastructure and raised land development.

It aims to manage flooding and groundwater risks while enabling resilient urban transformation, high-density housing, and long-term community viability while allowing space for water. This space for water provides a town-belt style amenity along the waterways.

The economic evaluation has not captured the potential for damages to be avoided through the proposed changes to planning rules to the east of Otaki Street.

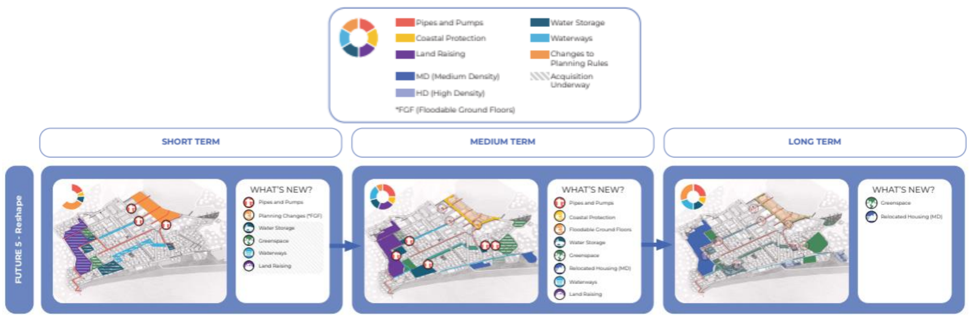

Figure 4-5: Future 5 – Interventions over the three-time epochs

Figure 4-6: Future 5 key details

5 BENEFITS

Consistent with the scope of work, we have sought to monetise the most significant benefits within the time available to do the analysis. We have identified where further effort could be directed for future stages of the SDF programme. We explain the two largest identified benefits below in more detail and share the other benefits that have been analysed at this stage.

5.1 ECONOMIC LOGIC AND TREATMENT OF BENEFITS

The economic evaluation follows a standard adaptation appraisal framework drawing on national and international guidance for long-term climate investment. The analysis assesses each proposed future by comparing its whole-of-life costs with the avoided damages and co-benefits achieved relative to the Status Quo.

This represents the unmanaged trajectory of Expected Annual Damage (AAD) as hazards increase over time. By framing benefits as "avoided losses," the evaluation ensures a direct and transparent link between the hazard modelling, residual risk results, and the economic outcomes.

The core logic of the appraisal centres on AAD as the primary monetised benefit category. AAD captures the annualised value of damage to buildings, infrastructure, and services arising from flooding and groundwater impacts, weighted by their probability.

$$NPV = PV(\text{Avoided Damages}) - PV(\text{Costs})$$

Where:

$$\text{Avoided Damages} = AAD_{DoNothing} - AAD_{Pathway}$$

The use of AAD allows the analysis to reflect both the increasing frequency and severity of hazard events as climate conditions change across the short (0–25 yrs), medium (26–50 yrs), and long (51–100 yrs) terms. AAD based avoided damages therefore provide a consistent, repeatable measure of the risk reduction value delivered by each Future.

While exposure metrics and illustrative maps in this report frequently reference the 2% AEP event for communication and consistency with hydraulic modelling outputs, monetised benefits are not based on a single event scenario. All headline benefit estimates are derived using AAD, which integrates multiple return periods and their associated probabilities. The 2% AEP outputs are therefore used as presentation and exposure proxies, whereas economic valuation is grounded in probability-weighted expected annual losses.

This ensures consistency with Treasury CBA practice, which requires expected-value (probability-weighted) loss estimation rather than reliance on single-event scenarios.

5.1.1 SEPARATION OF CORE AND SUPPLEMENTARY BENEFITS

To maintain clarity and reduce the risk of double counting, the analysis separates benefits into core and supplementary categories:

5.1.1.1 CORE BENEFITS

These are the directly evidenced, hazard-linked benefits that flow from reducing exposure and vulnerability. Core benefits include:

- avoided building and infrastructure damage,
- avoided emergency response and recovery costs,
- avoided health and wellbeing impacts associated with displacement, dampness, and trauma,
- avoided fatalities and injuries.

These benefits collectively represent the conservative, defensible foundation of the economic case. They align most closely with Treasury good practice expectations for climate resilience appraisal.

Care has been taken to avoid double counting across benefit categories. Property and infrastructure damage estimates reflect direct physical losses only. Human health, trauma, and social impacts are monetised separately using welfare-based valuation methods (e.g., Value of Statistical Life), ensuring that asset damage costs are not implicitly capturing these impacts.

5.1.1.2 SUPPLEMENTARY BENEFITS

These benefits are real but more uncertain in magnitude, attribution, or timing. They include:

- potential hedonic uplift from improved amenities (not included in this iteration),
- self-service improvements beyond risk reduction (not included in this iteration),
- level of service improvements beyond risk reduction (including reduced impacts on transport disruption and service outage) – included as a proportional benefit at this stage.
- co-benefits related to ecosystem services, urban regeneration, and long-term redevelopment.

Supplementary benefits are presented transparently as an upside scenario, separate from the core BCR. This approach allows decision makers to understand the minimum guaranteed value (core case) while recognising the potential additional value that may emerge as the programme matures and as further evidence is developed.

This two-tiered structure provides a clear, auditable assessment that supports both conservative decision making and the broader strategic case for multi-benefit adaptation investments.

5.2 AVOIDED PROPERTY DAMAGE

By far, this is the biggest benefit, making up approximately 80% of the total benefits, depending on the assumptions used.

5.2.1 METHODOLOGY

Currently, it is worth noting that natural hazards, such as flooding events, involve high levels of uncertainty around timing, frequency, and severity. To support the assessment, AAD was used.

This approach estimated the present value cost of flood damage to buildings in the catchment area over the 100-year timeframe, where benefits reflect changes in Expected Annual Damage (AAD), informed by modelling across multiple return periods. The calculation relied on the outputs from two models[10]. We took the outputs from both models at face value:

[10] AAD construction: For each epoch, the economic model applies the depth-damage function to the flood modelling outputs at three probability levels: 10% AEP (1-in-10-year event), 2% AEP (1-in-50-year event), and 1% AEP (1-in-100-year event). The resulting property damage estimates at each AEP are then probability-weighted to produce the

- Kia Rōpine provided flood modelling projections (known as the Efficacy modelling) for three flood event severities, undertaken at three different epochs (Present Day (aka Short Term), Medium Term and Long Term inside the study area.
- Depth Damage functions taken from Dunedin Council's Flood Damage Assessment (FDA) report were used to estimate the cost of flood damage to individual commercial and residential buildings and their contents, based on the flood modelling projections.

Approach steps:

- We received modelled outputs from each future for three pluvial flood events (a 10%, 2% and 1% AEP events). A current day and two future climate scenarios (in 2050 and 2080), for the existing urban form and the three potential futures. See Appendix A for the Coastal inundation approach.
- We applied the damage functions from DCC's FDA report to record damage costs for all residential, industrial, and commercial buildings and their contents for each scenario.
- We assessed against the Council's FDA, calculating total net present value but did not annualise.

We note that the use of the 'fixed' damages by depth for residential property is an approximation and doesn't allow for spatial, suburb style variations across the study area. The approach to Commercial and Industrial properties is, on the other hand, proportional to the Capital Value of the property, capturing spatial and asset type differences. This blended approach is likely to simplify the depth-damage relationship and, hence, bring the option-damage differences closer together.

Epoch-level benefit stacking: The 100-year assessment period is divided into three discrete epochs: short-term (0–25 years), medium-term (26–50 years), and long-term (51–100 years), each with its own modelled AAD reflecting the climate and land-use conditions representative of that period. Benefits in each epoch represent the NPV of avoided AAD relative to the Status Quo over the epoch duration. The whole-of-life BCR combines these three epoch-level NPVs.

This epoch-based structure is consistent with Treasury guidance for long-horizon public investment appraisal, which recognises that climate hazard conditions are not static and that benefits must reflect changing exposure over time. It avoids the alternative and less defensible approach of applying a single present-day AAD across the full 100 years, which would significantly understate the benefits of adaptation in the later decades when hazard intensity is greatest[11].

5.3 OTHER BENEFITS INCLUDED

We assessed other benefits after undertaking a further literature review to see if any other benefit types could be included at this stage. Following on from the Peer Review, we have revised the approach to avoid double counting of benefits (as described below).

Expected Annual Damage, using a trapezoidal integration approach consistent with standard flood risk analysis practice and Treasury CBA guidance on expected-value estimation. The AAD is therefore substantially lower than any single AEP event damage (e.g., Short Term AAD of $11m vs a 1% AEP single-event damage of $200m) because it reflects the full distribution of outcomes weighted by their annual probability.

[11] This approach aligns with The Treasury's Guide to Social CBA (2015) requirements for sensitivity testing across scenario conditions and with DEFRA/Environment Agency Flood and Coastal Erosion Risk Management Appraisal Guidance (2010), which recommends epoch-based benefit modelling for long-horizon flood risk investments.

The value of each individual benefit was relatively small compared to the two benefit classes identified above. This section describes each benefit type, with the monetisation approach and sources of assumptions detailed in Appendix A.

5.3.1 AVOIDED HUMAN COSTS

5.3.1.1 AVOIDED INJURY

With the Proposed Futures, it's expected that the various developments/interventions over the return period will gradually reduce the flood severity of a 2% AEP flood event in the South Dunedin catchment. Thus, the expected flood injury rate decreases under the Proposed Futures.

This has been modelled as the monetised cost savings of minor-moderate physical injuries avoided. Severe physical injuries are assumed to be fatal; hence it's captured under avoided fatalities. To avoid double-counting, psychological injuries avoided have been captured under trauma avoided.

The injury and fatality estimates are derived from probability-weighted exposure consistent with the 2% AEP event. Injury and fatality likelihoods are applied to the expected annual population exposure implied by the 2% AEP flood event scenario. This ensures that human impact estimates are aligned with expected-value risk modelling rather than event-based extrapolation.

5.3.1.2 AVOIDED FATALITY

Like the above, the Proposed Futures are expected to have lower flood injury occurrence, hence lower flood fatality occurrence. This has been captured in the economic evaluation as the monetised cost savings of fatalities avoided.

To avoid double counting, fatality and injury costs are treated as welfare losses (Value of Statistical Life and injury costs) and are not embedded within property damage values. Property damage estimates reflect physical asset loss only, while injury and fatality valuations capture societal welfare impacts separately.

5.3.2 AVOIDED RESPONSE AND RECOVERY COSTS

5.3.2.1 AVOIDED EMERGENCY SERVICE COSTS

Emergency service costs represent a legitimate and significant emergency response and recovery spending by the government, covering costs associated with immediate responses, search and rescue, debris removal, temporary accommodation & infrastructure and public cleanup, post a natural disaster.

In alignment with standard modelling practice, we have proxied flood emergency service costs as a constant proportion to total property damages. With the Proposed Futures, it's expected that it reduces both the property flood exposure and flood damage severity, driving down total property damages. This in turn reduces the expected emergency service costs, reflected in the economic evaluation as the monetised emergency service costs avoided.

5.3.2.2 AVOIDED SOCIAL COHESION COST

Extreme weather shocks such as floods likely negatively impact social cohesion (community fragmentation), resulting in economic hardship, increased vulnerability and community isolation. Based on the GIS mapping identified reductions in household flood exposure under each proposed future, the avoided negative social cohesion were monetised.

5.3.3 AVOIDED INCOME LOSS FROM DISPLACEMENT

Income loss from displacement refers to the income that is lost, disrupted and/or diminished when individuals, businesses, or communities are forced to relocate due to factors like natural disasters, environmental degradation, or large-scale development projects.

The GIS mapping for each proposed future identified the reduction in residential properties with exposure to greater or equal to 50% of its perimeter being flooded given a 2% AEP event. These exposure reductions are then used to monetise the aggregate household displacement time avoided within the South Dunedin catchment over the return period, assuming that those who are predicted to have above floor flooding will be displaced for an average of 13 weeks.

5.3.4 AVOIDED DIRECT AND INDIRECT TRAUMA

There are mental health (Trauma) costs associated with flooding. People exposed to the flood risk may worry about themselves being seriously injured (direct), and people connected to those exposed to the flood risk may be concerned about their safety (indirect). Literature concludes that people experience higher rates of anxiety, depression and post-traumatic stress disorder (PTSD) after a flood event.

GIS mapping identified the reduction in the number of residential properties that likely will be damaged by flood (direct) and the number of residential properties exposed to flood risk but unlikely to incur damages (indirect), under each proposed future.

These two GIS mapping identified reductions were adopted as proxies for the reduction in the number of households that would have likely experienced direct trauma (properties identified to be exposed to above floor flooding) and indirect trauma (residential properties with exposure to greater or equal to 50% of its perimeter being flooded given a 2% AEP event minus the direct trauma properties). The economic evaluation has monetised the expected reduction in the number of households exposed to direct and indirect trauma.

Treatment of benefit overlaps: The economic evaluation has been carefully structured to avoid double-counting across benefit categories. Three potential overlaps have been identified and managed as follows:

- Income displacement and direct trauma both draw on the same population of flood-affected households. These benefits are monetised using distinct welfare mechanisms, income displacement captures lost earnings, while direct trauma captures psychological harm – and do not overlap in their unit cost assumptions.
- Fatalities are a subset of the total injury population. Fatality costs use the Value of Statistical Life (VoSL) only; non-fatal injury costs use direct medical and productivity costs only. There is no double-counting between these two categories.
- Direct trauma and indirect trauma represent distinct populations with different flood exposure levels, monetised using different trauma likelihood rates from the literature.

5.3.5 AVOIDED ENVIRONMENTAL COSTS – WATER QUALITY DAMAGES

Water quality often becomes highly contaminated post severe weather events due to sewage overflows, agricultural runoff (sediment, nitrogen, phosphorus), and other pollutants, posing serious health risks and requiring extensive cleanup.

The economic evaluation has adopted household willingness to pay (WTP) to avoid water quality impairment as a proxy for the expected water quality damages resulting from a 2% AEP flood. Based on the GIS mapping identified reductions in the number of households exposed to flood risk, the economic evaluation could monetise the aggregate savings in household WTP.

5.3.6 *AVOIDED PROPERTY, BUILDING & INFRASTRUCTURE DAMAGES*

5.3.6.1 RESIDENTIAL, INDUSTRIAL AND COMMERCIAL PROPERTY DAMAGES AVOIDED

Buildings have been categorised into residential, commercial or industrial. Flood damage was then attached to each building for each flood event scenario assessed (modelled pluvial flood event or by geospatial analysis of coastal inundation exposure).

Multiple buildings are present within a land parcel as per the land use datasets used. GIS tools were used to identify parcels with multiple buildings within. The aggregated damages results removed duplications from the AAD calculation, through selecting the maximum flood affected building in each parcel and using this as the basis of the damage calculation for that address.

5.3.6.1.1 Pluvial Flooding Exposure

Based on GIS mapping, the economic evaluation has examined all properties and buildings exposed to flood risk and identified the buildings that are likely to have greater than 50% of their perimeter flooded during each of the three return periods modelled (the 10%, 2% and 1%AEP events). Flood damage estimates were then assigned to each flood-exposed building, reflective of building type and flood damage severity (See Appendix A for more information).

5.3.6.1.2 Coastal Flooding Exposure

For coastal flooding, the 'bathtub' flood modelling results available, has likely overestimated flood depths, and therefore reasonable approximations were made based on engineering judgement and consistency with the climate change risk assessment. This assumes that there is increasing frequency of coastal flooding over time due to sea level rise, consistent with Parliamentary Commissioner for the Environment (2015) research, and that all properties within the coastal flood zone are impacted to a limited degree from 2050 onwards.

Flood damage estimates were then assigned to each flood-exposed building, reflective of building type with parameters identified in consultation within Kia Rōpine team to reflect an 'appropriate' assessment at this early phase – See Appendix A for more information.

5.3.6.1.3 Summary

The economic evaluation has aggregated the expected total flood related property and building damages under each proposed future as an estimation of the total residential, industrial and commercial property damages with the difference between each future and the Status Quo, representing a benefit, as damages avoided.

5.3.6.2 INFRASTRUCTURE DAMAGES AVOIDED

The economic evaluation has assumed that above-ground infrastructure will be impaired to different degrees depending on the asset type, with respect to a flood level of 2% AEP. Using the GIS mapping identified total length of road that likely will be flooded under each proposed future as a proxy for the quantum of above-ground infrastructure that likely will be damaged under a flood, the economic evaluation has linked this with DCC's network valuation to monetise the likely infrastructure damages avoided.

5.3.7 HEDONIC ANALYSIS

Hedonic uplift represents capitalised increases in land or property value arising from reduced flood exposure. Because these gains can overlap with avoided property damage benefits, hedonic uplift is treated as a Supplementary Benefit. It is excluded from headline BCR calculations and reported separately for transparency only.

5.4 SUMMARY OF BENEFITS

The tables below summarise monetised benefits in present value terms, for each proposed future. A breakdown of these monetised benefits under each epoch are presented in Appendix B.

5.4.1 CORE BENEFITS INCLUDED

Table 5.1: Core monetised NPV benefits of Proposed Futures (Nearest $m).

Benefits – Entire Return Period ($m)	Future 3	Future 4	Future 5
Avoided Injury and Fatality	$416	$423	$426
• Injury	$55	$56	$56
• Fatality	$361	$367	$370
Avoided Response and Recovery Costs	$62	$62	$61
Avoided Income Loss from Displacement	$17	$17	$18
Avoided Trauma	$15	$15	$15
• Direct	$10	$10	$10
• Indirect	$5	$5	$5
• Social Cohesion	$0	$0	$0
Avoided Environmental Costs	$0	$0	$0
Avoided Property, Building & Infrastructure Damages	$825	$833	$816
• Residential, Industrial & Commercial	$822	$831	$813
• Infrastructure	$3	$3	$3
Total Benefits	$1,335	$1,351	$1,336

Taken from 20260331-CoreBCR+Coastal.xlsx

The relatively high value of avoided fatality costs reflects the application of nationally recognised Value of Statistical Life parameters over a 100-year horizon. While low-probability, high-consequence outcomes contribute materially to the monetised benefit stream, these estimates are probability-weighted and consistent with standard public-sector appraisal practice in New Zealand. The magnitude of these benefits reflects long-term cumulative risk exposure rather than frequent annual loss.

5.4.2 WITH SUPPLEMENTARY BENEFITS

Table 5.2: Supplementary monetised NPV benefits of Proposed Futures (Nearest $m).

Benefits – Entire Return Period ($m)	Future 3	Future 4	Future 5
Avoided Injury and Fatality	$416	$423	$426
• Injury	$55	$56	$56
• Fatality	$361	$367	$370
Avoided Response and Recovery Costs	$35	$35	$34
• Emergency Services	$35	$35	$34
Avoided Income Loss from Displacement	$17	$17	$18
Avoided Trauma	$15	$15	$15
• Direct	$10	$10	$10
• Indirect	$5	$5	$5
• Social Cohesion	$0	$0	$0
Avoided Environmental Costs	$0	$0	$0
Avoided Property, Building & Infrastructure Damages	$464	$473	$455
• Residential, Industrial & Commercial	$462	$470	$452
• Infrastructure	$3	$3	$3
Hedonic Analysis	$305	$181	$322
• Level of service	$305	$181	$322
Total Benefits	$1,640	$1,532	$1,657

6 COSTS

6.1 INTRODUCTION AND CONTEXT

To assess the implications of the Proposed Futures, associated costs have been estimated. The cost estimates are based on a high-level optioneering and efficacy modelling exercise undertaken by the Kia Rōpine team, consisting of a series of spatially represented adaptation options/measures that are aggregated up into one of the three proposed future scenarios. This section describes each core cost type, with the approach, unit rates and source, detailed in Appendix A.

6.2 ONE OFF COSTS

The economic evaluation has identified one-off costs as the largest project costs, namely the capital costs associated with the construction of new infrastructure assets to support each future, followed by the acquisition of property and land identified to provide the space for retrofitting the interventions for each future.

6.2.1 INFRASTRUCTURE CAPEX

The identified options/assets incorporated within each Future are based on engineering judgment. They represent ***one potential combination of the quantity and the type of treatment options / assets at specific alignments and locations, to achieve an identified and modelled resulting efficacy***. Based on the agreed engineering judgment and the resulting schedule of quantities and developed unit rates, the economic evaluation has estimated the likely associated costs.

The costs reflect a high-level estimation and are intended to be ***comparative only for this stage***, given the remaining uncertainty, particularly in relation to the selections of short-, medium- and long-term options that may combine as part of the future.

Modelling whole-of-life costs for each future allows a fair comparison of the three proposed futures, as it factors in the timing of cost occurrence. It is expected that the cost estimates will improve further in accuracy as the project progresses to reflect further analysis on costings and timings.

Each option cost estimate is based on a typical detail for that option, calculated in accordance with available rates from a range of recent similar projects across New Zealand. The cost estimates follow established good practice methodologies underpinned by the Treasury's Better Business Case guidance.

Cost timing assumptions are captured in Appendix A, with appropriate inflation, discounted back to the present. ***A formal review of the unit rates has been proposed but not yet commenced.*** We have allowed the whole-of-life costs of:

- Construction capital costs including allowances for demolition, site clearance, utility services replacement, and reinstatement.
- Construction preliminaries and generals (P&G)
- Operation and maintenance costs
- Professional and internal management fees
- Contingency and optimism bias

- Acquisition of properties – purchase of landholdings and buildings

Capital costs have been adjusted to reflect optimism bias consistent with Treasury Better Business Case guidance for non-standard civil engineering projects at this stage of development. Given the early stage of option definition and design maturity, the upper-bound optimism bias adjustment (66%) has been applied to capital costs.[12]

This approach aligns with Treasury Better Business Case recommendations for projects at strategic concept stage, where scope definition and risk resolution remain incomplete. The optimism bias allowance can be progressively reduced as design development and cost certainty improve in subsequent phases.

The selected optimism bias percentage reflects the project's current position within the Better Business Case lifecycle and recognises uncertainties relating to scope refinement, geotechnical risk, property acquisition complexity, consenting requirements, and construction staging.

Exclusions at this stage of development include GST, contaminated waste disposal, unexpected ground conditions, rebuild of existing properties in new location, escalation or operational costs/downtime due to operations.

Unit costs do not reflect the potential opportunities to offset costs, for example through property acquisition via renting or through selling land suitable for intensification after elevating it. For this phase of the study, the costs provided are those that are likely to be funded through Council (or rather through 'public funding'), although alternative funding mechanisms could be put in place as opportunities are captured into the future. The cost estimates do not include costs borne by individual property owners to reduce risk.

6.2.1.1 CORE ASSUMPTIONS

- Programme duration for each option has been assumed to be the same for each outcome with the costs identified as being based on current conditions.
- Most construction details have been assumed. We have built up our rates using judgement at this point and using previous projects to guide the ranges being applied.
- Allowances have been made to provide for the mobilisation and demobilisation of key plant and equipment required for each project. As the project progresses, we will get a better understanding of these factors.
- Quantities have been taken from the received layout and draft sizing exercise undertaken as part of the efficacy modelling (see Key Assumptions below).
- Costs only included for the South Dunedin study area. Note that assets that protect the area from coastal flooding/erosion will need to extend beyond the study area. Assumed these costs would be captured in other budgets to reflect the additional lengths of these assets with an appropriate & consistent level of protection for the central Dunedin area. These costs would be additional to the numbers presented.
- No costs included for the protection activities required for the St Clair to St Kilda coastal edge. Should on-going Coastal investigations/assessments identify that further protection is required then this cost would be additional to the numbers presented.

[12] Te Tai Ōhanga | The Treasury – techniques to quantify risk and uncertainty – Optimism Bias - https://www.treasury.govt.nz/information-and-services/state-sector-leadership/investment-management/better-business-cases/additional-better-business-case-guidance/techniques-quantify-risk-and-uncertainty.

6.2.2 PROPERTY & LAND ACQUISITION

The Property and Land Acquisition cost component captures the economic implications of proactive purchase of land and buildings required to enable for repurposing of land, elevated-land development, or blue-green infrastructure interventions. Key inputs include:

- The quantum of buildings identified under each option (residential, commercial, and industrial).
- Property-specific capital values, based on DCC provided 2025 property Capital Value (CV).
- Timing of acquisition aligned with intervention phases.

Acquisition costs grow over time through the same cost escalation factors applied elsewhere in the model, ensuring consistency with long-term general market cost escalation. These costs are allocated based on intervention periods and discounted to reflect present-value terms.

The approach provides a transparent, standardised method to compare acquisition-heavy options (e.g., extensive property repurpose or land regrading) against infrastructure dominant options.

6.2.3 REPURPOSED LAND ACTIVITES

Through the assessment work for each future, including the overlay of specific strategic interventions (options such as Raised Land in Future 3 and 5, or Green Open Space), a geospatial analysis of potential properties (all types) required to be ***proactively repurposed*** to provide space for the delivery of the specific options for each future.

The costs included within this reflect the activities to remove existing assets from the identified future intervention parcels. Further details are presented in Appendix A, capturing

- Removal or demolition of properties
- Land Clearing – removing utilities and other assets.
- Reinstatement of the current property land to green space.

6.3 ONGOING COSTS

The economic evaluation has identified incremental capital maintenance costs and asset operating expenses associated with the construction of new infrastructure assets, recurring over the assessment period.

6.3.1 CAPITAL MAINTENANCE

Capital maintenance represents periodic reinvestment required to maintain asset performance over its designed life. The core assumption being asset capital maintenance cost is equivalent to 35% of the initial capital investment, required every 25 years after the initial capitalisation of the asset. These costs are evaluated at their respective renewal intervals and escalated using the model's scenario-specific cost growth factors before being discounted back to present value.

This generalised approach provides a suitable option-based asset lifecycle maintenance envelope. Ensuring high-capital, long-life structural interventions are evaluated on a like-for-like basis with nature-based or repurpose-heavy Futures. Including these renewal costs avoids underestimating long-run costs of engineered solutions and supports a balanced option comparison.

6.3.2 OPEX

Ongoing operational expenditure (OPEX) covers the recurring activities necessary to operate, monitor, and maintain the performance of implemented interventions, whether blue-green systems, piped networks, pumped drainage, or other structural / non-structural measures.

The OPEX calculation is applied annually across the assessment timeframe, accounting for inflation and discounting back to present value. The core assumptions are that the annual operational costs are allocated as a percentage of the total capital asset worth, set at 1.5% per year. Costs are cumulative, with additional investment resulting in operational expenditure being added.

Additionally, electrical annual line charges and energy costs are included for pump station assets on top of the proportional capital investment. The modelling assumes that the energy demand annually increases into the future.

This produces a lifecycle-based estimate of long-term operational commitments, which is critical when comparing options with high ongoing energy or maintenance loads (e.g., pump-reliant "Keep Water Out" configurations).

6.4 SUMMARY OF COSTS

6.4.1 ENTIRE PERIOD

The table below summarises the monetised costs in present value terms, for each future over the full return period. A breakdown of these monetised costs under each epoch is presented in Appendix B.

Table6.1 – Total Costs by future – whole of life (2025 NPV $m, 6% discount rate)

Core component	Status Quo	Future 3 Protect	Future 4 Restore	Future 5 Reshape
CAPEX Investment	$290	$1,220	$724	$1,287
Repurposed Land Activities	$4	$433	$447	$545
Land & Property Acquisition	$72	$343	$338	$519
Capital Maintenance (cyclical)	$15	$33	$39	$31
Operational Expenditure (OPEX)	$31	$70	$81	$66
Total Costs	$411	$2,098	$1,629	$2,448

7 COMPARISON WITH PREVIOUS STAGES

7.1 THE OUTCOMES

Table 7.1 – Differences between presented Long- & Proposed Futures.

Futures	Long List (2025 -2100)				Short List (2027 -2127) - Core			
	Cost ($B)	Benefits ($B)	BCR	Rank	Cost ($B)	Benefits ($B)	BCR	Rank
Future 3 Protect	5.8 (5.0 – 8.0)	3.8 (3.5 – 4.5)	0.6 (0.4 – 0.8)	*3*	2.1	1.34	0.64 (0.54 – 0.75)	*2*
Future 4 Restore	2.8 (2.0 – 4.0)	2.8 (2.5 – 3.5)	1.0 (0.6 – 1.6)	*1*	1.6	1.35	0.83 (0.71 – 0.98)	*1*
Future 5 Reshape	7.1 (6.0 – 10.0)	4.5 (4.0 – 5.5)	0.7 (0.4 – 0.9)	*2*	2.4	1.34	0.55 (0.46 – 0.64)	*3*

7.2 CORE ASSUMPTION CHANGES

7.2.1 APPROACH TO THE ASSESSMENTS

As part of the Long List phase, no quantifiable assessments or evidence was utilised to assess the potential quantum of properties and infrastructure affected, or likely to be purchased because of various proposed interventions. Engineering judgement was utilised to assess the likely scale of interventions that could yield a suitable improvement in the exposure to both groundwater and stormwater flooding for the current day and future conditions.

The interventions at both Long and Short List were mapped using geospatial information based on the catchment knowledge. The quantity of each asset proposed was then used within the economic assessment to determine the potential costs for each future. Each of the seven futures created a series of interventions that made up each future.

7.2.1.1 LENGTH OF ASSESSMENT

Following discussions with the client and a review of the general practices for social investment proposals and climate resilience investment planning, the economic evaluation has increased the assessment period from 75 years to 100 years to better model long-term flood hazards and adjusted the present term (baseline date) from 30 June 2025 to 1 January 2027 to reflect a more realistic project start date.

7.2.1.2 TIMING OF THE INTERVENTIONS

At the Long List phase, core assumptions as to when costs and benefits would be incurred where simplified, given the status of the investigation at that time. The Short List stage has allowed for further investigation into determining when options would be delivered across the three modelled epochs.

Table 7.2 below captures the core differences between the two phases completed to date

Table 7.2: Monetised Costs of Proposed Futures Over the Entire Return Period

Item	Long List	Short List
Purchase of Properties	• All properties purchased within first 5 - 15 years of each future. • Average property value for South Dunedin - $450k (2022 CV).	• Proactive acquisition distributed into each epoch. Evenly spread across the epoch period. • Asset specific Capital Values (2025 CV)
Included Flooding Damage Assessments	• Qualitative assessment of all forms of flooding and impacts on properties.	• Quantitative pluvial and semi-quantitative coastal property level assessments.
Infrastructure Investments	• Capital investment for each future delivered within the first 5 - 15 years.	• Capital investments for each epoch spread across the first 10 years of each epoch.
Benefits period	• Benefits accrue from year 1.	• Benefits accrue from year 1 of each epoch onwards
Basis of Economic Assessment	• Assumed impacts of 1% AEP event into the future.	• AAD applied as described above.

7.2.2 PROPERTIES TO BE ACQUIRED

At the Long List phase, property acquisition was assessed at a strategic level through the micro-business cases and the seven potential adaptation futures. These early assessments considered indicative numbers of properties requiring purchase under each future, informed by GIS mapping and the initial spatial adaptation envelopes.

The analysis provided high-level, order-of-magnitude estimates to support shortlisting and was not yet linked to hydraulic performance modelling, with the Status Quo using engineering judgement to identify the likely quantum of affected properties.

The modelling at the Short List stage defines spatial exposure for each future, enabling a more defendable, hydraulically-informed count of affected properties and associated acquisition costs.

The cost modelling workbook then applies these property counts, capital values, cost-growth indices, and discounting assumptions to produce monetised acquisition costs consistent with the timing and scale of the actions within each Futures scenario. This represents a progression from high-level strategic estimates (early 2025), to efficacy-aligned and spatially validated cost estimates in the current stage.

Table 7.3: Quantity and monetised costs of properties for acquisition - assumed (Long-List) or assessed (Short-List) – 2025 CV

Futures	Long List		Short List	
	Quantity *1	$ B *3	Quantity *2	$ B *4
Future 3 - Protect	3,450	1.56	1,190	0.59
Future 4 - Restore	1,375	0.62	1,162	0.45
Future 5 - Reshape	3,750	1.69	1,738	0.84

*1 -Assumed number of buildings to be ‘no longer suitable for residential purposed’ during Long List and for Short List Status Quo – based on a geospatial assessment undertaken that identifies when properties could be exposed to emergent groundwater over the next 100 years[6], with the assumption that land associated with these low-lying buildings would be repurposed, due to anticipated untenable living conditions.

*[2] - Buildings calculated using geospatial analysis for proactive acquisition only (because of the identification of land area to be utilised for future options/mitigations).

*[3] – Long list costs included assumptions (no quantitative analysis undertaken) identifying the number of buildings to be acquired (proactively – to make space for specific adaptation mitigations being implemented) or through purchase post events (assumed costs worn by mix of public and local/central government), multiplied by an average cost of $450k per property (QV Average CV 2025 for South Dunedin[13]).

*[4] – Number of buildings to be acquired proactively taken from geospatial assessment, multiplied by the rateable value for the specific property (taken from DCC dataset received), with a 15% allowance for costs associated with purchasing the property included. Specific assessment identifies that buildings affected represented residential, commercial, industrial, school and church buildings.

7.2.3 MITIGATION OPTIONS HAVE BEEN FURTHER REFINED

There have been further refinements to the likely infrastructure required to achieve the anticipated outcomes in relation to exposure. The efficacy work undertaken has reviewed and iteratively determined a suite of options within a hydraulic model environment, with the quantities and sizes of assets specifically captured. The Long List was a qualitative assessment undertaken in GIS to identify likely needs of infrastructure for each future. Table 7.4 overleaf captures the differences between the two phases.

7.2.4 PROPERTY PURCHASE FOR STATUS QUO

The previous phase included approximately $1.2 billion dollar of reactive property acquisition within the Status Quo costs as properties become more increasing exposed to flooding, more regularly, with expected insurability and mortgage-ability challenges.

In line with recent Government direction changes and an anticipated shift away from purchasing properties damaged by Natural Hazard events, this phase of the assessment does not include these costs within the economic evaluation. With the assumed impacts of exposure for buildings and finances (through the AAD calculation) rising through the Medium- and Long- Term.

Status Quo excludes the financial impacts of these from the overall public finances assessment. These are still expected to occur but will now be borne by the private purse (the property owners themselves) – presenting a considerable equity and intergenerational challenge.

[13] Taken from Figure 1 of DCC Flood Risk Assessment Technical Note (February 2025), produced by Stantec as part of the Integrated Catchment Modelling Programme.

Table 7.4: Comparison of core infrastructure changes between Long and Short List phase

Physical Works	Future	Status Quo		Future 3 - Protect		Future 4 - Restore		Future 5 - Reshape	
	Unit	Long List	Short List	Long List	Short List	Long List	Short List	Long List	Short List
Open Channels	m	0	0	0	0	4500	3526	10000	3526
Overland flow paths	m	0	0	11000	0	7500	0	6500	0
Storage - 1m deep	ha	-	0	-	1	-	1	0	1
Storage - 1.5m deep	ha	40	12	70	4	65	4	75	4
Storage - 2m deep	ha	-	0	-	0	-	2	0	2
Wetlands	ha	0	0	0	9	0	9	0	9
Pump Station - Small (under 1m^3/s)	ea	0	0	0	6	0	6	0	2
Pump Station - Large	m^3/s	2	6	10	12.4	10	12.3	10	11.8
GW Pump Station	ea	1	0	1	1	1	1	1	1
Repurposed Land Area	ha	40	0	125	81	65	69	195	102
Raised Land	ha	0	0	55	39	0	0	120	45
New pipe to outfall	m	0	500	2000	0	2000	0	2000	0
New Outfall	ea	1	1	1	4	1	4	1	3
New seawall (Minimum length in SDF Area)	m	0	0	2000	2100	2000	2100	0	0
Internal sea wall / bund (Minimum length in SDF Area)	m	0	0	0	0	0	0	1500	1500
Groundwater pipes network / inspection vents	m	49000	0	32000	10000	49000	16000	32000	9500
Stormwater Pipes (diameter > 900mm)	m	-	4000	8000	9291		9184		8985
Stormwater Pipes (diameter < 900mm)	m	-	9000	12000	21439		23381		25309
Manholes - Sum (all sizes)	ea	-	540	400	673		821		853
Demolition and Site Clearance	Section	2500	10	3750	1190	3450	1162	1375	1738
Utility services	ha	40	2	125	95	65	85	195	118
Reinstate	ha	0	0	60	81	0	69	120	102
Land Acquistions / Compensation	ea	2500	10	3450	1190	1375	1162	3750	1738
Properties exposed to elevated groundwater	ea		838						
Value (2025) of buildings retreated	$B	$ 1.10	$ 0.94	$ 1.60	$ 0.59	$ 0.60	$ 0.45	$ 1.70	$ 0.84

8 BCR RANGE

8.1 SUMMARY

The analysis for this phase produces a benefit cost ratio for each future (Figure 8-1), showing a significant reduction in the expected annual flood damages of over $810m over the 100-year period.

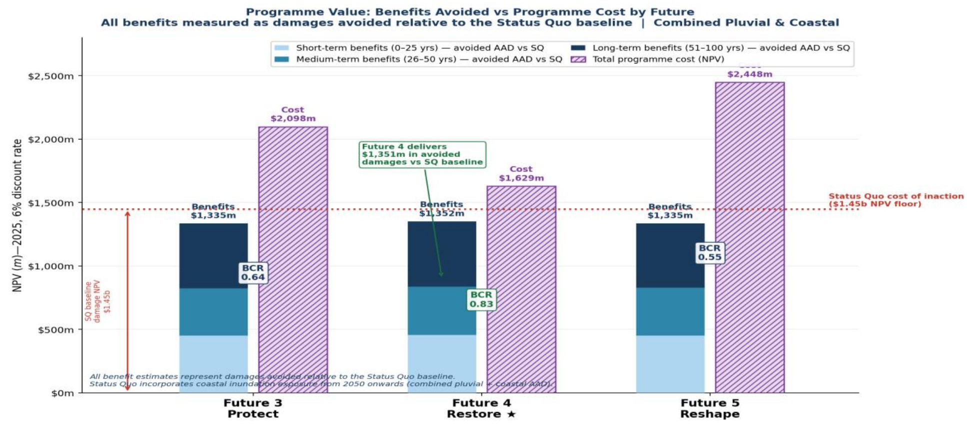

Figure 8-1: Programme Value: Cumulative Avoided Damage (Benefits) vs Programme Cost by Future[14]

8.1.1 CORE BCR

Table 8.1 – Core BCR – whole of life (2025 NPV $m, 6% discount rate)

Future	Benefits	Costs	Core BCR (midpoint)	BCR range (±15%)	Rank
Future 3 - Protect	$1,335	$2,098	0.64	0.54 – 0.75	2
Future 4 - Restore	$1,351	$1,629	0.83 ★	0.71 – 0.98	1
Future 5 - Reshape	$1,336	$2,448	0.55	0.46 – 0.64	3

To date, we present the BCR using a range, sufficient for the high-level concept stage of the analysis, with no design undertaken to date. There is uncertainty about the underlying assumptions and inputs. The range presented at this stage, differs from the ranges presented at Long List phase, dated February 2025, as identified within Section 7.

Further economic evaluation will take place during the subsequent stage, which should continue to narrow the range, as input certainty will start to increase. Appendix B shares the BCR breakdown by each of the three epochs.

[14] All benefits = damages avoided relative to Status Quo baseline (NPV $m, 6% discount rate, 2025 $).Methodology note: Stacked bars show NPV avoided damages by epoch: Short-term (0–25 yrs), Medium-term (26–50 yrs), Long-term (51–100 yrs). Hatched bars show whole-of-life programme costs. Dotted line = Status Quo cost of inaction ($1.45b NPV). All benefit estimates derived from combined pluvial and coastal AAD relative to the Status Quo.

The Long-Term (51–100 year) BCRs are notably stronger than the whole-of-life BCRs. This reflects the timing profile of the Futures: most capital costs are incurred in the Short- and Medium-Term, while a large share of risk-reduction benefits accrues later as climate hazards intensify.

When assessed on a standalone basis, the long-term period shows high value for money because relatively modest incremental costs are used to avoid very large future damages. Higher Long-Term BCRs relative to whole-of-life BCRs mainly reflect timing and discounting effects, rather than a modelling anomaly.

The whole-of-life BCR combines all three epochs and is therefore influenced by (i) the concentration of costs in the early decades and (ii) the discounting of distant benefits. This pattern is consistent with international practice in climate-adaptation cost-benefit analysis, where upfront capital investment is compared with benefits that grow over time as hazards intensify.

Path to benefit-cost breakeven: The current Core BCR for Future 4 is 0.83 at the central 6% rate. For the BCR to reach 1.0, the NPV of benefits would need to increase by $300m from their current modelled value.

This could be achieved through further work through to the subsequent Preferred Pathway, with a combination of:

- quantifying insurance withdrawal avoidance (not currently included, estimated to be potentially material given post-Cyclone Gabrielle insurance withdrawal patterns in low-lying NZ communities);
- including regeneration and urban land value uplift benefits;
- quantifying avoided utility and infrastructure network costs (Chorus and Transpower assets within the study area are not currently included);
- determining additional hedonic analysis values, reflecting enhancements to transport levels of service (such as through reducing potential transport disruption and their impact on the local economy),
- refining the optimism bias downward from 66% as design certainty improves.

The BCR range should therefore be read as a conservative floor, not a ceiling, on the programme's economic performance.

8.1.2 SUPPLEMENTARY BCR

Table 8.2 – Supplementary BCR – whole of life (2025 NPV $m, 6% discount rate)

Future	Benefits	Costs	Core BCR (midpoint)	BCR range (±15%)	Rank
Future 3 - Protect	1,640	2,098	0.78	0.66 – 0.92	2
Future 4 - Restore	1,532	1,629	0.94 ★	0.80 – 1.11	1
Future 5 - Reshape	1,657	2,448	0.68	0.58 – 0.80	3

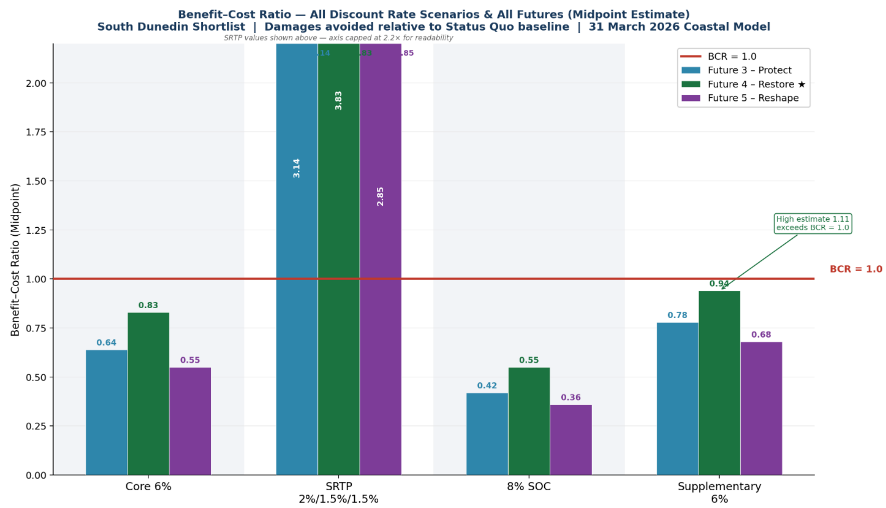

Figure 8-2: Core Benefit-Cost Ratio – All Scenarios & All Futures (Midpoint Estimate)[15]

8.2 SENSITIVITY TESTING

We undertook some sensitivity analyses to identify the assumptions that had the biggest impact on the benefit cost ratio. In this report, the 'Status Quo' future represents a continuation of current and planned BAU/LTP investment, without the additional proposed adaptation interventions, present in Futures 3 - 5. The following sensitivity tests were undertaken to strengthen robustness and address peer-review recommendations:

8.2.1 DISCOUNT RATES

Adopting New Zealand Treasury's suggested 2025 SRTP for non-commercial public-sector proposals as the low-discount-rate scenario, the headline BCRs improve. The following analysis is undertaken using both a low discount rate to represent a Social Rate of Time Preference approach (with a rate of 2% for the short-term epoch, declining to 1.5% for the medium-term and 1.5% for the long-term, consistent with NZ Treasury's public investment discount rate guidance.

Under the SRTP scenario (2%/1.5%/1.5%), all three proposed futures exceed the benefit-cost breakeven threshold. Future 4's Core BCR improves to 3.83, Future 3 to 3.14, and Future 5 to 2.85. This result reflects the incorporation of coastal inundation exposure into the Status Quo baseline, which materially increases the damages avoided under each future scenario and, therefore, the benefits at all discount rates.

[15] This figure presents the midpoint Benefit–Cost Ratio for each proposed future across four discount rate scenarios. All BCRs reflect damages avoided relative to the Status Quo baseline (combined pluvial and coastal AAD). The Status Quo BCR is excluded from the chart as the three proposed futures are assessed relative to it; Status Quo BCR values are provided in the accompanying tables. The core 6% rate is the headline discount rate used throughout this evaluation. The SRTP scenario (2%/1.5%/1.5% declining across short, medium, and long terms) represents the Treasury benchmark for long-lived public investment; under this scenario all three proposed futures exceed the benefit-cost breakeven threshold of 1.0. The 8% SOC scenario represents the high-end sensitivity. The supplementary scenario incorporates a Level of Service proxy in addition to core avoided damage benefits. SRTP bars are truncated at 2.2 for chart readability; actual midpoint values are annotated above each bar.

The finding strongly confirms that the proposed futures deliver substantial positive net social value under the Treasury's public investment discount rate framework and do so by a significant margin above the BCR = 1.0 threshold when assessed on an appropriate intergenerational basis.

Table 8.3 – Low Discount rate applied BCR – whole of life (2025 NPV $m, 2% & 1.5% discount rates)

Future	Benefits	Costs	Core BCR (midpoint)	BCR range (±15%)	Rank
Future 3 - Protect	14,052	4,479	3.14	2.67 – 3.69	2
Future 4 - Restore	14,132	3,685	3.83 ★	3.26 – 4.51	1
Future 5 - Reshape	13,957	4,904	2.85	2.42 – 3.35	3

Adopting New Zealand Treasury's suggested 2025 SOC for commercial public sector proposals as the high discount rate scenario of 8, the headline BCRs worsen.

Table 8.4 – High Discount rate applied BCR – whole of life (2025 NPV $m, 8% discount rate)

Future	Benefits	Costs	Core BCR (midpoint)	BCR range (±15%)	Rank
Future 3 - Protect	707	1,687	0.42	0.36 – 0.49	2
Future 4 - Restore	716	1,298	0.55 ★	0.47 – 0.65	1
Future 5 - Reshape	708	1,986	0.36	0.30 – 0.42	3

This range reflects common practice for long lived public infrastructure and climate adaptation investments, where discounting must balance intergenerational equity and fiscal realism.

8.2.2 PRIVATE LEVEL PROPERTY ADAPTATION UPTAKE

A further sensitivity run was undertaken to determine the impact of an increasing level of property level flood resilience interventions added by a proportion of the property owners (all land use types) over the next 30 – 50 years. To undertake this analysis, we reduced the expected annual average damage per epoch to 85% of the Status Quo expected Annual Average Damages.

The implications of this are that there are marginal reductions in the BCR, but the proportional change for each Future is the same and hence the BCR ranking remains the same.

Table8.5 – Sensitivity applied – 15% reduction in AAD – for Private investment in Property Level adaptations – whole of life (2025 NPV $m, 6% discount rate)

Future	Benefits	Costs	Core BCR (midpoint)	BCR range (±15%)	Rank
Future 3 - Protect	1,206	2,098	0.57	0.49 – 0.68	2
Future 4 - Restore	1,222	1,629	0.75 ★	0.64 – 0.88	1
Future 5 - Reshape	1.206	2,448	0.49	0.42 – 0.58	3

9 CONCLUSION

The economic evidence supports investment in adaptation, and Future 4 (Restore) is the recommended option of the three shortlisted. At a central 6% discount rate, the community would spend approximately $280 million in net present value terms to avoid an estimated $1.45 billion in flood-related damages, plus a further $500–700 million in unquantified consequences such as insurance withdrawal, infrastructure repair, and private adaptation costs that South Dunedin residents would otherwise bear directly.

The relevant comparison is the net cost of action versus the cost of inaction. The programme costs shown in Table 1.2 and Table 6.1 are gross figures and do not net off the avoided damages each future delivers. Once avoided damages are considered, the net cost of each proposed future sits materially below the cost of inaction, as set out in Table 9-1 below.

Table 9-1: Net cost of action versus cost of inaction (NPV $m, 6% discount rate, 100-year period)[16]

Option	Gross programme cost	Avoided damages	Net cost to the community	Saving versus inaction
Status Quo	—	—	$1,450m+	baseline
Future 3 — Protect	$2,098	$1,335	$763	≈ $687m
Future 4 — Restore ★	$1,629	$1,351	$278	≈ $1,172m
Future 5 — Reshape	$2,448	$1,336	$1,112	≈ $338m

The cost of inaction should be read as a range: $1.45 billion (the conservative quantified floor) to more than $2 billion (inclusive of unquantified consequences). Both ends of that range exceed the net cost of any of the three proposed futures. Under the Treasury Social Rate of Time Preference framework, which is the appropriate discount basis for long-lived intergenerational public investment, all three futures return Core BCRs above 1.0, with Future 4 at 3.83, Future 3 at 3.14, and Future 5 at 2.85. This confirms that the economic case for adaptation in South Dunedin is robust under the discount rate framework most appropriate to a 100-year climate adaptation programme

While whole-of-life Core BCRs are below 1 in the current shortlisting assessment, long-lived climate adaptation investments are typically characterised by significant upfront capital costs and benefits that increase over time as hazard intensity escalates.

This pattern is consistent with comparable long-lived public infrastructure investments in New Zealand and internationally. For context, NZ transport infrastructure investments routinely proceed with BCRs in the 0.4–0.8 range at the business case stage, on the basis that additional unquantified benefits (network effects, resilience value, social equity) support the investment case.

The long-term (51 – 100 year) BCR results and sensitivity testing demonstrate strengthening economic performance over time and confirm that relative Futures ranking remain stable under alternative discount rate assumptions. It's expected that the BCRs would improve as the economic evaluation develops. The results should therefore be interpreted as indicative of relative economic performance at strategic concept stage, rather than as definitive investment thresholds for final approval.

[16] Cost of inaction is the conservative quantified floor of $1.45 billion NPV. Inclusive of unquantified consequences (insurance withdrawal, wider infrastructure repair, private adaptation), the cost of inaction is likely more than $2 billion, which would widen the saving to community under each future accordingly. Gross programme costs from Table 6.1; avoided damages from Table 5.1.

Further upside has been excluded from the Core BCR work at this time but further effort to understand and appropriately include the potential for regeneration uplift as well as the benefits of avoided losses in open space, avoided losses in ecosystem services, avoided damages in heritage buildings and value of insurability to be included.

Alongside ongoing refinements in the modelling, with the considerations for wider-economic benefits, and potentials for cost efficiencies and optimisation.

Each year without action increases costs: Annual Average Damage rises by roughly $1m per year in the medium term and accelerates as climate risks worsen. Capital costs also rise about 2% annually. Starting early on the preferred plan, even before all details are final, is likely more cost-effective than delaying further.

As the programme progresses, it is expected that the opportunities for further evaluation of redevelopment potential will progress further and will provide more specific analysis for inclusion into the next stage of our assessments. At this stage, we have identified a conservative assessment and have identified the basis of this in this report.

Even if some private adaptation and BAU responses reduce the Status Quo AAD further over time, indicative sensitivity testing suggests that the relative performance and ranking of the Proposed Futures is likely to remain robust under reasonable levels of private intervention.

The shortlist economic evaluation suggests that Future 4 is the most beneficial. Future 4 yields the highest BCR of ***0.83*** over the full return period, central 6% discount rate, indicating the strongest return of the three proposed futures assessed. Initial sensitivity testing confirms this to be the favoured future, based on the evaluated economics included here.

Furthermore, under the Social Rate of Time Preference (SRTP) scenario, appropriate for long-lived public investment. Future 4's BCR improves to ***3.83***, exceeding the breakeven threshold of 1.0. Initial sensitivity testing confirms Future 4 as the preferred future based on the evaluated economics.

Current GIS mapping suggests that, under the Status Quo future, following the assumption of the same level of flood risk within South Dunedin, groundwater levels are expected to gradually increase over the return period. This suggests increasing consequences for maintaining current communities within South Dunedin.

In the absence of further local government interventions than proposed under the Status Quo scenario, South Dunedin is expected to become increasingly intolerable to reside and work in. There will be some level of private sector flood mitigation investment expected, such as property owners paying to raise their own land or relocating their land improvements.

Appendix A – Core Economic Assumptions: Sources and discussion

Discount rate

A discount rate is used to convert flows of costs and benefits over time into a net present value. Following The Treasury's guidelines on determining the discount rate for government projects[17], a weighted average of the two approaches of social opportunity cost (SOC) and social rate of time preference (SRTP) was deemed most appropriate.

All headline BCRs use a 6% weighted Social Opportunity Cost (SOC), consistent with NZ Treasury public sector guidance for long-lived social infrastructure. Following Treasury's guidance, the economic evaluation has been sensitivity tested using a high discount rate of 8% (representing the real SOC of capital) across the full assessment timeframe, and a low discount rate applying real Social Rate of Time Preference (SRTP) rates of 2%, 1.5%, and 1.5% for the short-term, medium-term, and long-term periods respectively[18].

These SRTP rates are derived from NZ Treasury's long-term GDP growth projections adjusted for the Fisher equation, reflecting a conservative estimate of the declining real rate of return over the 100-year assessment period. These rates are broadly consistent with international practice for long-lived climate adaptation investment, where declining discount rates over time are increasingly accepted (e.g., UK Green Book declining long-run discount rate framework).

They are marginally below the NZ Treasury standard SRTP of approximately 3–3.5%, which reflects a more conservative treatment of intergenerational equity. The SRTP sensitivity BCR results (Future 4: *3.83*) are therefore based on rates at the lower end of the defensible range.

Benefits

Avoided injury

The National Institutes of Health (NIH) studies concluded minor-moderate physical flood injury rates of between 2% and 4.6%[19] . The economic evaluation adopted the NIH midpoint injury likelihood of 3% and applied it to the population of exposure under each proposed future. The evaluation assumed an average direct cost per minor-moderate injury of $68,083 as suggested by the NZIER and an average indirect cost per minor-moderate injury of $272,332 (400% of direct cost)[20].

Avoided Injury = NPV of [AEP * population of exposure * injury rate * (direct cost per injury + indirect cost per injury)]

Avoided fatality

The economic evaluation adopted the literature-suggested flood caused minor-moderate injuries to severe injuries ratio of 6028:1075[21] and applied this to the expected number of injuries under each proposed future over the return period. The evaluation embraced the NZIER and NZTA suggested value of statistical life (VoSL) of $12.5M per life.

The NZ Treasury's 2024 guidance indicates a VoSL range of $12.75m to $14.0m (with a midpoint of approximately $13.375m). The evaluation adopts the conservative NZIER/NZTA figure of $12.5m,

[17] Young, L. (2002). Determining the Discount Rate for Government Projects. Econstor.

[18] Discount Rates. (2025). The Treasury New Zealand. https://www.treasury.govt.nz/information-and-services/public-sector-leadership/guidance/reporting-financial/discount-rates

[19] Bartholdson, S., & von Schreeb, J. (2018). Natural Disasters and Injuries: What Does a Surgeon Need to Know? Current Trauma Reports, 4(2), 103–108. https://doi.org/10.1007/s40719-018-0125-3

[20] Clough, P. 2023. The value of safety improvements." NZIER Insight 107. Available at https://www.nzier.org.nz/publications/the-value-of-safety-improvements-nzier-insight-107

[21] Terti, G., Ruin, I., Anquetin, S., & Gourley, J. J. (2017). A Situation-Based Analysis of Flash Flood Fatalities in the United States. Bulletin of the American Meteorological Society, 98(2), 333–345. https://doi.org/10.1175/bams-d-15-00276.1

which is marginally below the Treasury 2024 lower bound. Updating to the Treasury 2024 midpoint ($13.375m) would increase avoided fatality benefits by approximately 7%, with a marginal upward impact on the overall BCR. This refinement is recommended for the next stage.

Avoided Fatality = NPV of [AEP * population of exposure * injury rate * fatality rate given injury * VoSL]

Avoided emergency services cost

NZIER's economic assessment of flood risk mitigation addressed to the Greater Wellington Regional Council suggested that flood emergency services costs within New Zealand range between 4% to 11% of the total property damages[22]. The economic evaluation has adopted the midpoint flood emergency service cost range in NZIER's study of 7.5% as the assumed flood emergency cost, with respect to total property damages.

Avoided Emergency Service Cost = NPV of [emergency cost% * expected total property damages]

Avoided income loss from displacement

The GIS mapping has identified the likely households exposed to relocation risk with respect to flooding within the model catchment. The economic evaluation has assumed that households subject to flooding will be displaced for, on average, 13 weeks.

It is further assumed that severe injuries are fatal, hence, the associated income losses have already been captured under fatality costs avoided. The average annual household income in Dunedin in present terms, published by Infometrics, is $111,805 per household.

Avoided Income Loss from Displacement = NPV of [AEP * expected number of household displacements * average annual household income * displacement duration]

Avoided trauma

The GIS mapping has estimated the number of households that are likely to be directly and indirectly affected by flooding under the Proposed Futures over the return period, assuming an average household size in Dunedin of 3 people (rounded up from 2.5 per NZ Census data).

Literature review suggests that 22.1% of the exposed households will likely experience direct trauma, with a current monetary cost of $24,200 per person[23], and 32.5%[24] of the connected households will likely experience indirect trauma, with a current monetary cost of $12,100 per person[25].

Directly impacted – Refers to all residential properties identified through the efficacy modelling work to have above floor flooding, given a 2% AEP event.

Indirectly impacted – refers to all residential properties with exposure to greater or equal to 50% of its perimeter being flooded given a 2% AEP event minus the Directly impacted trauma properties.

Avoided Trauma = NPV of [AEP * average household size * (expected households directly impacted * direct trauma likelihood * cost of direct trauma per person + expected households indirectly impacted * indirect trauma likelihood * cost of indirect trauma per person)]

Avoided social cohesion cost

[22] NZIER. 2024. Economics of Flood Risk Mitigation. A report for Greater Wellington Regional Council and Rivers Group of Regional Councils.

[23] von der Warth, R., Dams, J., Grochtdreis, T., & König, H. H. (2020). Economic evaluations and cost analyses in posttraumatic stress disorder: a systematic review. European Journal of Psychotraumatology, 11(1). https://doi.org/10.1080/20008198.2020.1753940

[24] Terti, G., Ruin, I., Anquetin, S., & Gourley, J. J. (2017). A Situation-Based Analysis of Flash Flood Fatalities in the United States. Bulletin of the American Meteorological Society, 98(2), 333–345. https://doi.org/10.1175/bams-d-15-00276.1

[25] Even, D., Cohen, G. H., Wang, R., & Galea, S. (2024). The cumulative contribution of direct and indirect traumas to the production of PTSD. PLoS ONE, 19(8), e0307593–e0307593. https://doi.org/10.1371/journal.pone.0307593

The economic evaluation has estimated the likely social cohesion cost by assuming a reduction in GDP growth per capita of 2.2%, as suggested by a recent macroeconomic implication study on severe flood events published by the OECD Economics Department[26]. The GDP per capita in Dunedin is presented in current terms by Infometrics as $64,506.

Avoided Social Cohesion Cost = NPV of [AEP * GDP per capita * social cohesion cost factor * population of exposure]

Avoided water quality damage

The economic evaluation has reviewed the findings presented in the New Zealanders Environmental Attitudes 2018 report published by the Ministry for the Environment and has adopted the probability of households concerned for water quality of 82%.

The evaluation has approximated the expected Dunedin resident WTP to avoid water quality damages as $100 per person in current terms, based on an indexation to current values of the New Zealand literature study highlighting the Auckland residents' WTP for moderate water quality improvements of $74.53[27].

Avoided Water Quality Damages = NPV of [AEP * impacted households * probability of households concerned for water quality * average household size * estimated resident WTP]

Avoided residential, industrial & commercial property damage

GIS mapping has modelled the likely flood level for the identified buildings. Where the flood level is above the building's floor level, we have then estimated the likely flood damage severity to the buildings and grouped them on a discrete scale between 0 (low to no damage) and 4 (catastrophic damage).

Flood damage estimates have been assigned to each flood-exposed building, depending on building type and flood damage severity, based on the agreed methodology that DCC have requested for the analysis.

The approach is presented in the Integrated Catchment Modelling Programme output "DCC Flood Risk Assessment Technical Note", published February 2025.The table below shares an example of the damage implications to Residential and Commercial buildings that are exposed to flooding.

Residential (Modal)		
Total Building and Contents		
Flood depth (mm)	Category	Cost
None	0	0
-100 to 0	1	$10,000
0 to 200	2	$45,000
200 to 500	3	$170,000
500 to 2000	4	$300,000

Commercial		
Total Building and Contents		
Flood depth (mm)	Category	Cost
		(* building capital value)
None	0	0
0 to 200	1	0.07
200 to 500	2	0.62
500 to 1000	3	1.58
1000 to 2000	4	1.92

Industrial		
Total Building and Contents		
Flood depth (mm)	Category	Cost
		(* building capital value)
None	0	0
0 to 200	1	0.06
200 to 500	2	0.46
500 to 1000	3	0.85
1000 to 2000	4	1.14

Avoided Property Damages = NPV of [AEP * expected total property damages]

Duplicated buildings - The results from V3 of the work onwards, has reported the most flood affected building in each parcel and captured these within the AAD calculations. Further manual review identified that address points (particularly commercial assets) had several parcels related to

[26] Costa, H., & Hooley, J. (2025). The macroeconomic implications of extreme weather events. OECD Economics Department Working Papers. https://doi.org/10.1787/5e24a2d8-en

[27] Walsh, P. J., Guignet, D., & Booth, P. (2023). Eliciting policy-relevant stated preference values for water quality: An application to New Zealand. Agricultural and Resource Economics Review, 52(2), 347–378. https://doi.org/10.1017/age.2023.20

one address and its capital value. For this assessment, a manual review for properties showing over $3m damage per event was undertaken for each scenario and return period result.

Coastal flooding – All buildings identified within the study area to be exposed coastal inundation (from the Risk Assessment work) were included within the analysis and could have flood damages calculated. Duplicated buildings were screened out so as to report one building per address. Flood damages were assigned to the resulting buildings as follows:

Table A-1: Application of Damages for coastal flooding assessment (Based on DCC FDA, 2025)

BUILDING LAND USE	FLOOD CATEGORY APPLIED	RESULTING COST ADDED TO EACH ADDRESS (DCC, 2025)
Commercial, school & church	2	0.62 x Capital Value
Industrial	2	0.46 x Capital Value
Residential	Floor level dependent	Floor level >= 0.3m - $45,000 Floor level < 0.3m - $170,000

These damages were then summed to deliver the total coastal damage exposure (TCDE). With the identified PCE, 2015 work showing increasing likelihood of inundation with rising sea level, we then applied a weighting to the epoch-based damage assessment to arrive at an annualised damage (in line with the Pluvial approach) with the increasing likelihood of inundation captured over time by the application of proportional exposure, such that:

- Medium Term – Average damages from applying (2% x TCDE) + (1% x TCDE)
- Long Term – Average damages from applying (2% x TCDE) + (1% x TCDE) + (10% x TCDE).

A more refined, depth-based assessment could support the subsequent Preferred Pathway stage.

Avoided infrastructure damage

Upon a review of the flood-related infrastructure repair spending with New Zealand[28], the guide to the cost of road civil construction in New Zealand[29] and DCC's infrastructure portfolio optimised depreciated replacement cost (ODRC), the economic evaluation has assumed an average infrastructure ODRC of $2.5m/km of road.

Avoided Infrastructure Damages = NPV of [expected length of road damaged * infrastructure ODRC per km of road * impairment level]

Gains in land improvement value – For information (not in this phase)

Literature shows a consistent discount in property values near a floodplain. Motu Economics and Public Policy Research suggests that the value discount reflecting proximity to a floodplain ranges between 4% and 8% of the total property value[30]. The economic evaluation has assumed a land improvement value discount of 6% (midpoint).

[28] Selwyn District Council - severe weather - latest updates. (n.d.). https://www.selwyn.govt.nz/news-And-events/news/archived/severe-weather-latest-updates-2021

[29] Ultimate Guide to Cost of Civil Construction NZ - Civil Construction Wellington. Civil Construction Wellington. https://civilconstructionwellington.nz/cost-of-civil-construction-nz/

[30] Storey, B., Noy, I., Owen, S., Townsend, W., Kerr, S., Salmon, R., Middleton, D., Filippova, O., & James. (2017). Insurance, Housing and Climate Adaptation: Current Knowledge and Future Research. Zenodo (CERN European Organization for Nuclear Research). https://doi.org/10.5281/zenodo.842898

Gains in Land Improvement Value = NPV of [expected proceeds from sale of reinstated land improvements * (1 + floodplain improvement premium)]

Gains in land redevelopment premium – For information (not in this phase)

To capture the benefits of land raising, the economic evaluation has assumed a land redevelopment premium of 6%.

Gains in Land Value Premium = NPV of [expected proceeds from sale of raised land * (1 + land redevelopment premium)]

Gains in level of service – For information (not in Core BCR. Shown within Supplementary BCR)

To capture the gains in level of service as a return on new infrastructure capital investment, the economic evaluation has assumed a level of service return of 25% with respect to infrastructure capital investment.

Gains in Level of Service = NPV of [level of service return * infrastructure investment

Costs

Key Cost Assumptions for each Future

Proactive Repurpose - Clearing space for the future interventions to be delivered.

- House Purchase – For the properties identified for removal to make space for appropriate interventions, Capital Valuation of property used for each affected property. 2025 QV values received from Council on September 19th (RateAssessmentProperty_SD.shp)
- Allowances for building removal at $50k per property to move/demolish the building. No allowance for any benefit from resale of the moved properties (e.g., as 'relocated dwellings').
- Removal of utility services – allowance of $2.5m per hectare given the urban nature of the environment. The exact extent, nature, and purpose of these is unknown at this stage and represents a large uncertainty. Including for reasonable costs associated with delivery of an engineered clear surface ready for the overlay of construction activity related to either storage, green open space, raised land or other.
- Costs associated with protecting or removing specific utilities' equipment have not yet been factored into the estimate. Chorus South Dunedin facility and Transpower key substation on Otaki St – are large and important assets to the community and wider South Island.
- Allowances have been made for reinstatement, including removal / replacement of all vegetation including grass, low shrubs, and trees. The exact extent of these is unknown at this stage - $35k per hectare.
- Property Purchase – the 2025 capital value per property has been used, received from DCC during September. An additional allowance of 25% has been included to capture legal costs, above market rate purchase price potential and costs associated with applying potential compulsory purchase orders.

Capital Costs - Options / measures estimates

- Raised Land – Allowance of $10m per hectare raised to capture material, compaction, and reasonable ground engineering requirements. Edge protection of raised land included. Representing a 2.5m average increase in land topography. Effectively $400 / m^2 / m depth.
- Open Waterway - Allowances of $10k per metre, Prices based on recent Blue Green Network cost estimates rounded. Representing a 30m wide corridor with a two-stage channel. Base channel 5m wide and 1.5m deep, side slopes of 1:4 with secondary flood plain used as corridors for paths / vegetation / habitat.
- Pump Stations – Assumed at a rate of $2.5m per m^3/s pumped, for each of the groundwater specific or stormwater asset. Not inclusive of land purchase costs, investigations, or design fees. For pump stations under 1m^3/s a flat rate of $3m applied for that pump station.
  - Annual costs added to the Operational / Maintenance costs – as per rule below. Additional annual cost included (anticipated energy costs for use), following these assumptions.
    - GW – Assumed that will require constant use (52 weeks per annum) from day one.
    - SW – Assumed that the energy use will increase over time, based on
      - ST – 2 weeks per annum
      - MT – 4 weeks per annum
      - LT – 8 weeks per annum
- New outfall to coastal marine environment – allowance of $15m per outfall for an outfall to represent situation of discharge to higher energy environment off south coast.
- Groundwater network – inclusion of appropriate level of network (based on servicing existing public roads within the area identified to be at elevated risk of groundwater emergence with a 1.1m SLR at 2100 – $3.5k per metre (identified core locations for additional network needed (as per each option)). Removed need for GW network in raised areas as under assumption that the land changes do not impact on GW management needs.
- Coastal defences - Internal sea wall – assumed design to be less engineered and consist of raised bund able provided inland of the existing coastline to be able to hold high tidal events out of the South Dunedin area. Allowance of $10k per metre.
- Coastal defences - Engineered sea wall along the inner harbour, rock faced with approximately 3m height with 1:4 slopes and top width able to carry existing roadway around harbour. Allowance of $35k per metre.
- Stormwater storage basins. Costs inclusive of excavation, lining, outlet structures, and appropriate landscaping:
  - 1m deep - Allowance for $3m per hectare.
  - 1.5m deep - Allowance for $4m per hectare.
  - 2m deep - Allowance for $4.5m per hectare.
- Wetlands – Allowance for $5m per hectare with base approximately 1m below current ground surface. Costs inclusive of excavation, lining, outlet structures, and appropriate landscaping.
- Contaminated land & unanticipated large, buried material – Incorporated a proportional increase in the capital costs for each of the mitigation option that interacts with below ground activities. Unit costs escalated by 35% for the options that require digging/trenching.

Table A-2: Stormwater pipe costs

SW PIPES (MM)	SUPPLY COST ($ / METRE)	BASE INSTALL MULTIPLIER*1	DEWATERING ALLOWANCE*2 ($ / METRE)	UNIT COST RATE USED IN ASSESSMENT ($ / METRE)
100	65	2.6	150	319
150	75			345
200	85			371
225	95			397
250	105			423
300	250			800
375	325			995
450	375	3.2	300	1,500
525	425			1,660
600	475			1,820
675	525			1,980
700	550			2,060
750	575			2,140
900	750			2,700
1050	900	4	550	4,150
1200	1,025			4,650
1300	1,100			4,950
1500	1,150	5	900	6,650
1200x900	1,650			9,150
1200x1000	1,750			9,650
1500x1000	1,950			10,650
1500x1300	2,150			11,650
1800x700	2,050			11,150
2000x1000	2,350			12,650
2000x1500	2,750			14,650
2100x1000	2,450			13,150
2100x1050	2,550			13,650
3000x1000	3,150			16,650
3000x1200	3,350			17,650

Notes

*1 *Base install multiplier (excluding dewatering)*: reflects trenching, shoring, laying, bedding, backfill, compaction, pavement reinstatement, TMP, etc., but not dewatering. Multipliers rise with pipe size due to trench width, depth, shoring, and reinstatement effort—typical in urban environments. (Method choice and complexity increase with excavation size and ground conditions.)

*2 *Dewatering allowance* a per-metre figure sized by pipe class (as a proxy for typical trench depths/widths). Higher allowances reflect the need for wellpoints/deep wells, continuous pumping, monitoring, and discharge treatment in high-water-table areas. (Dewatering is a major driver of delays and cost; discharge often requires treatment/consents in urban settings.)

Table A-3: Manhole costs

MANHOLES (MM)	SUPPLY COST ($ / UNIT)	BASE INSTALL MULTIPLIER*1	DEWATERING ALLOWANCE*2 ($ / METRE)	UNIT COST RATE USED IN ASSESSMENT ($ / METRE)
0.8	1,300	4	600	5,800
0.9	1,400			6,200
1	1,500			6,600
1.2	1,700	5	1200	9,700
1.3	2,100			11,700
1.5	2,350			12,950
1.6	2,550	6	2000	17,300
1.7	2,750			18,500
1.8	2,950			19,700
1.9	3,150			20,900
2.2	4,750	7	3500	36,750
2.6	5,750			43,750
3	7,000			52,500
3.3	7,750			57,750
4	11,000	8	6000	94,000
5.2	16,500			138,000
6	20,000			166,000
6.4	23,500			194,000
10	37,500	10	10000	385,000

Table A-4: Sump costs

MANHOLES (MM)	SUPPLY COST ($ / UNIT)	BASE INSTALL MULTIPLIER*1	DEWATERING ALLOWANCE*2 ($ / METRE)	UNIT COST RATE USED IN ASSESSMENT ($ / METRE)
0.6	1,150	3.5	400	4,425
0.7				
0.8				
0.9				
1				
1.2	2,650	4.5	900	12,825
1.3				
1.7				
3	7,000	6	2500	44,500

Notes

*1 *Base install multiplier (excluding dewatering)*: reflects trenching, shoring, laying, bedding, backfill, compaction, pavement reinstatement, TMP, etc., but not dewatering. Multipliers rise with pipe size due to trench width, depth, shoring, and reinstatement effort—typical in urban environments. (Method choice and complexity increase with excavation size and ground conditions.)

*2 *Dewatering allowance* a per-metre figure sized by pipe class (as a proxy for typical trench depths/widths). Higher allowances reflect the need for wellpoints/deep wells, continuous pumping, monitoring, and discharge treatment in high-water-table areas. (Dewatering is a major driver of delays and cost; discharge often requires treatment/consents in urban settings.)

Operational / Maintenance Costs

- Annual maintenance costs for capital options (not including the costs in Section 3.2.2.1) – 1.5% of the discounted Capital Cost per annum.
- Pumping Stations include assessment of annual energy costs based on assumed use per annum and annual line charge.
- Cyclical Capital maintenance costs for capital options (not including the costs in Section 3.2.2.1) – 35% of the discounted Capital Cost every 25 years.

Exclusions

- GST
- Legal or marketing costs
- Operational costs/downtime due to operations
- Rebuild of existing properties in new location.

Appendix B - Summary tables for Benefits and Costs (for the three epochs).

Benefits Tables per Epoch for the Core BCR.

Short-term

Observed from the economic evaluation of the Proposed Futures over the short-term, the avoided costs and damages are all identical under the three futures (the Efficacy modelling (termed as Present Day)), reflecting the evaluation approach of an identical level of flood risk reduction spread over the short-term period, following an equivalent annual annuity (EAA) approach.

Table B-1: Monetised Benefits of Proposed Futures Over the Short-Term (NPV $m)

Benefits Short-Term ($m)	Future 3 - 5
Avoided Injury and Fatality	$262
Injury	$35
Fatality	$227
Avoided Response and Recovery Costs	$12
Avoided Income Loss from Displacement	$10
Avoided Trauma	$9
Direct	$6
Indirect	$3
Social Cohesion	$0
Avoided Environmental Costs	$0
Avoided Property, Building & Infrastructure Damages	$159
Residential, Industrial & Commercial	$158
Infrastructure	$1
Total Benefits	$452

Medium-term

Observed from the economic evaluation of the Proposed Futures over the medium-term, following the consistent application of the EAA approach, the expected costs and damages avoided have dropped compared to the short-term, largely due to the implication of discounting.

Table B-2: Monetised Benefits of Proposed Futures Over the Medium-Term (NPV $m)

Benefits Medium-Term ($m)	Future 3	Future 4	Future 5
Avoided Injury and Fatality	$102	$106	$109
Injury	$13	$14	$14
Fatality	$88	$92	$94
Avoided Response and Recovery Costs	$18	$19	$18
Avoided Income Loss from Displacement	$4	$5	$5
Avoided Trauma	$4	$4	$4
Direct	$3	$3	$3
Indirect	$1	$1	$1
Social Cohesion	$0	$0	$0
Avoided Environmental Costs	$0	$0	$0
Avoided Property, Building & Infrastructure Damages	$244	$248	$242
Residential, Industrial & Commercial	$243	$247	$242
Infrastructure	$1	$1	$1
Total Benefits	$372	$381	$378

Long-term

Observed from the economic evaluation of the Proposed Futures over the long-term, flood exposure and flood consequences have dropped dramatically, as an outcome of the combined capital investments undertaken over the course of the previous epochs.

Table B-3: Monetised Benefits of Proposed Futures Over the Long-Term (NPV $m)

Benefits Long-Term ($m)	Future 3	Future 4	Future 5
Avoided Injury and Fatality	$53	$55	$55
Injury	$7	$7	$7
Fatality	$46	$48	$48
Avoided Response and Recovery Costs	$32	$32	$31
Avoided Income Loss from Displacement	$3	$3	$3
Avoided Trauma	$2	$2	$3
Direct	$2	$2	$2
Indirect	$1	$1	$1
Social Cohesion	$0	$0	$0
Avoided Environmental Costs	$0	$0	$0
Avoided Property, Building & Infrastructure Damages	$422	$422	$415
Residential, Industrial & Commercial	$421	$421	$415
Infrastructure	$1	$1	$1
Total Benefits	$511	$514	$507

Overall

Table B-4: Monetised Benefits of Proposed Futures Overall (NPV $m)

Benefits Long-Term ($m)	Future 3	Future 4	Future 5
Avoided Injury and Fatality	$416	$423	$426
Injury	$55	$56	$56
Fatality	$361	$367	$370
Avoided Response and Recovery Costs	$62	$62	$61
Avoided Income Loss from Displacement	$17	$17	$18
Avoided Trauma	$15	$15	$15
Direct	$10	$10	$10
Indirect	$5	$5	$5
Social Cohesion	$0	$0	$0
Avoided Environmental Costs	$0	$0	$0
Avoided Property, Building & Infrastructure Damages	$825	$833	$816
Residential, Industrial & Commercial	$822	$831	$813
Infrastructure	$3	$3	$3
Total Benefits	$1,335	$1,351	$1,336

Costs Tables per Epoch

Short-term -The quantum of capital works is relatively similar across the three Proposed Futures in the short-term, whereby capital expenditure and operational expenditure are roughly identical in present value terms. There is no expected capital maintenance required in the short-term.

Table B-5: Monetised Costs of Proposed Futures Over the Short-Term (NPV $m)

Costs – Short Term ($m)	Status Quo	Future 3	Future 4	Future 5
Infrastructure CAPEX	$216	$912	$486	$992
Repurposed land activities	$0	$384	$436	$477
Property & Land Acquisition	$24	$279	$338	$445
Capital Maintenance	$0	$0	$0	$0
OPEX	$14	$23	$23	$23
Total Costs	**$254**	**$1,598**	**$1,284**	**$1,938**

Medium-term - The assessed costs in the medium-term are observed to be lower than in the short-term, largely due to the later costs incurring greater discounting.

Table B-6: Monetised Costs of Proposed Futures Over the Medium-Term (NPV $m)

Costs – Medium Term ($m)	Status Quo	Future 3	Future 4	Future 5
Infrastructure CAPEX	$74	$299	$229	$294
Repurposed land activities	$4	$49	$10	$68
Property & Land Acquisition	$18	$64	$0	$74
Capital Maintenance	$7	$13	$13	$13
OPEX	$11	$27	$34	$26
Total Costs	**$115**	**$452**	**$287**	**$475**

Long-term - Like the above, long-term costs are lower due to the bulk of capital and property repurposing costs incurred in the short to medium term, with greater discounting over time.

Table B-7: Monetised Costs of Proposed Futures Over the Long-Term (NPV $m))

Costs – Long Term ($m)	Status Quo	Future 3	Future 4	Future 5
Infrastructure CAPEX	$0	$9	$9	$0
Repurposed land activities	$0	$0	$0	$0
Property & Land Acquisition	$29	$0	$0	$0
Capital Maintenance	$7	$20	$25	$18
OPEX	$6	$19	$24	$17
Total Costs	**$43**	**$48**	**$58**	**$35**

Overall

Table B-8: Monetised Costs of Proposed Futures Overall (NPV $m))

Costs – Long Term ($m)	Status Quo	Future 3	Future 4	Future 5
Infrastructure CAPEX	$290	$1,220	$724	$1,287
Repurposed land activities	$4	$433	$447	$545
Property & Land Acquisition	$72	$343	$338	$519
Capital Maintenance	$15	$33	$39	$31
OPEX	$31	$70	$81	$66
Total Costs	$411	$2,098	$1,629	$2,448

BCR tables per epoch for Core BCR assessment

Short-term

Table B-9: Comparison of Futures Over the Short-Term (NPV $m)

FUTURE	BENEFITS ($M)	COSTS ($M)	BCR	RANK
Future 3	$452	$1,598	0.28	2
Future 4	$457	$1,284	0.36	1
Future 5	$450	$1,938	0.23	3

Medium-term

Table B-10: Comparison of Futures Over the Medium-Term (NPV $m)

FUTURE	BENEFITS ($M)	COSTS ($M)	BCR	RANK
Future 3	$372	$452	0.82	3
Future 4	$381	$287	1.33	1
Future 5	$378	$475	0.80	2

Long-term

Table B-11: Comparison of Futures Over the Long-Term (NPV $m)

FUTURE	BENEFITS ($M)	COSTS ($M)	BCR	RANK
Future 3	$511	$48	10.61	2
Future 4	$514	$58	8.86	3
Future 5	$507	$35	14.58	1

Overall

Table B-12: Comparison of Futures Overall (NPV $m)

FUTURE	BENEFITS ($M)	COSTS ($M)	BCR	RANK
Future 3	$1,335	$2,098	0.64	2
Future 4	$1,351	$1,629	0.83	1
Future 5	$1,336	$2,448	0.55	3

That the public be excluded from the following items under LGOIMA 48(1)(a):

1.1 Minutes of Council 25 February 2026

3.1 Appointment of an Independent Member to the Audit & Risk Committee

The general subject of each matter to be considered while the public is excluded, the reason for passing this resolution in relation to each matter, and the specific grounds under section 48(1) of the Local Government Official Information and Meetings Act 1987 for the passing of this resolution are as follows:

General subject of each matter to be considered	Reason for passing this resolution in relation to each matter	Ground(s) under section 48(1) for the passing of this resolution
2.1 Minutes of Council 25 February 2026	To protect information where the making available of the information—would be likely unreasonably to prejudice the commercial position of the person who supplied or who is the subject of the information – Section 7(2)(b)(ii). To enable any local authority holding the information to carry out, without prejudice or disadvantage, commercial activities – Section 7(2)(h)	Section 48(1)(a); Subject to subsection (3), a local authority may by resolution exclude the public from the whole or any part of the proceedings of any meeting only on 1 or more of the following grounds: (a)that the public conduct of the whole or the relevant part of the proceedings of the meeting would be likely to result in the disclosure of information for which good reason for withholding would exist.
3.1 Appointment of an Independent Member to the Audit & Risk Committee	To protect the privacy of natural persons, including that of deceased natural persons – Section 7(2)(a)	Section 48(1)(a); Subject to subsection (3), a local authority may by resolution exclude the public from the whole or any part of the proceedings of any meeting only on 1 or more of the following grounds: (a)that the public conduct of the whole or the relevant part of the proceedings of the meeting would be likely to result in the disclosure of information for which good reason for withholding would exist.

This resolution is made in reliance on section 48(1)(a) of the Local Government Official Information and Meetings Act 1987 and the particular interest or interests protected by section 6 or section 7 of that Act or section 6 or section 7 or section 9 of the Official Information Act 1982, as the case may require, which would be prejudiced by the holding of the whole or the relevant part of the proceedings of the meeting in public.