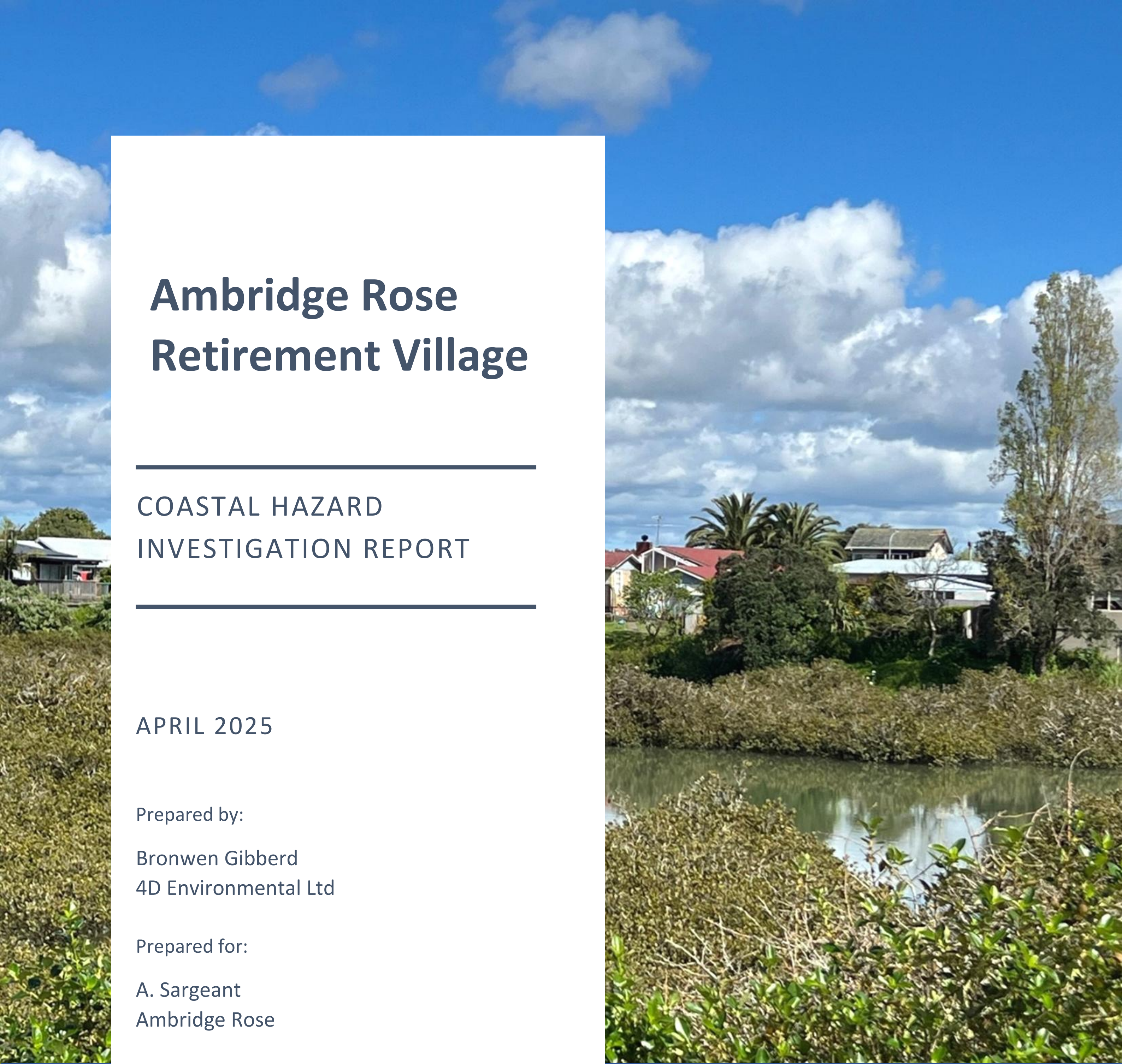

Ambridge Rose Retirement Village

COASTAL HAZARD INVESTIGATION REPORT

APRIL 2025

Prepared by:

Bronwen Gibberd
4D Environmental Ltd

Prepared for:

A. Sargeant
Ambridge Rose

Contents

Introduction and Description of Proposed Works 3
Physical Setting 4
Coastal Processes 5
Tides and Water Levels 5
Wave Climate 5
Sea Level Rise 6
Coastal Inundation Hazard 7
Coastal Erosion Hazard 8
Site Visit 9
Aerial Photo Analysis 10
Coastal Erosion Hazard Area 11
Coastal Hazard Risk 13
Coastal Inundation Risk 13
Coastal Erosion Risk 13
Summary 15
Recommendations 16

Introduction and Description of Proposed Works

This report considers coastal hazards at the site of the proposed Ambridge Rose Retirement Village, 147-153 Edgewater Drive, Pakuranga. This provides an update on a previous coastal hazard assessment prepared for a proposed development on the site (November 2002) and a response to a request for further information prepared in May 2023. A revised development has been proposed that increases the height and alters the footprint of the buildings.

Two buildings are proposed (Block A and Block B) (Figure 1). Block A is approximately 5 m from the coastal property boundary and 12 m from the toe of the bank at the southern corner. Block B is approximately 6 m from the property boundary and 15 m from the toe of the coastal bank.

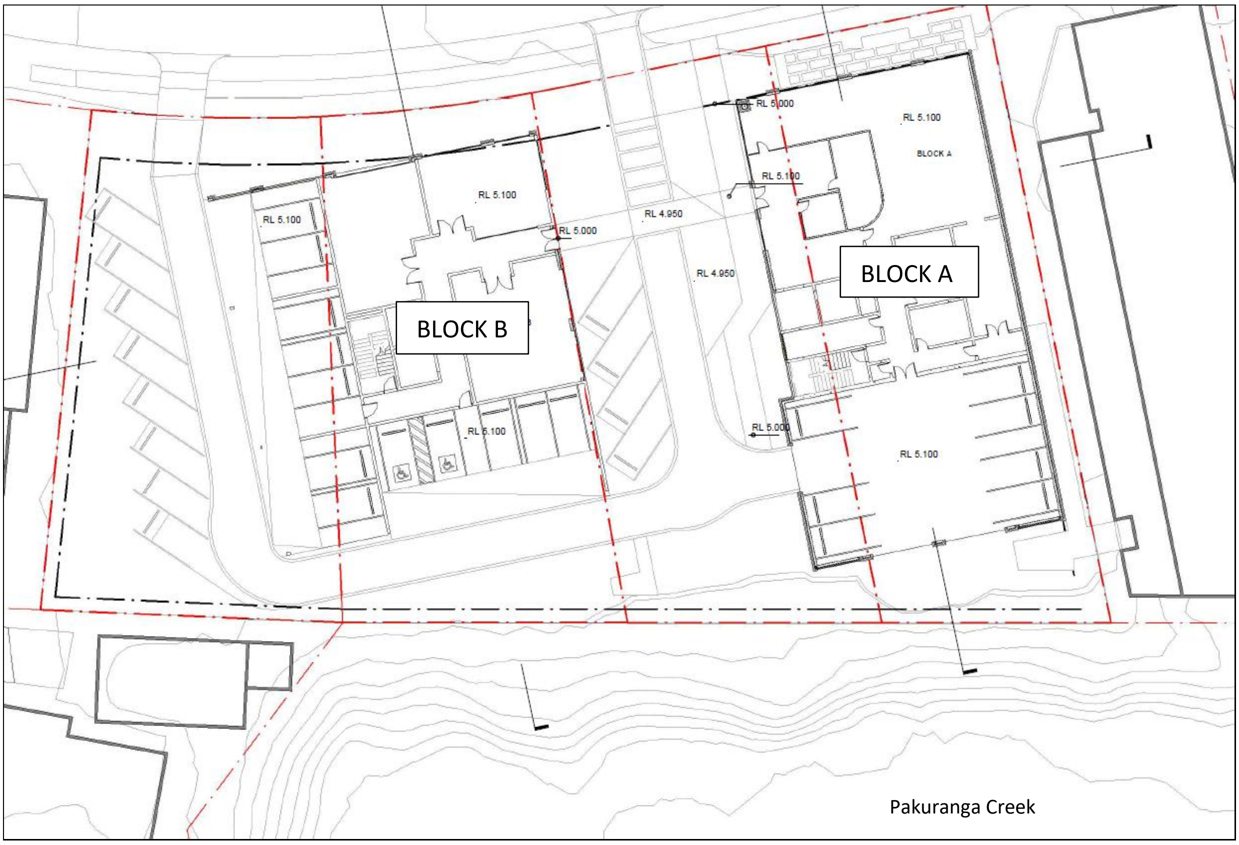

Figure 1: Proposed development (ground floor) at 147-153 Edgewater Drive. Source: Peddle Thorp, 2025[1].

Both proposed new buildings are partially within the Areas Susceptible to Coastal Instability and Erosion ("ASCIE") defined by Auckland Council (Figure 2). These areas have been defined based on the regional assessment of Roberts et al. (2020)[2] and highlight the potential for coastal erosion hazard to affect the proposed development. This report provides a site-specific consideration of likely coastal hazard in relation to the proposed development.

[1] Peddle Thorp Aitken Ltd, 2025: Site Plan 2114 – RC-2-002 - Ambridge Rose.

[2] Roberts, R., N Carpenter and P Klinac (2020). Predicting Auckland's exposure to coastal instability and erosion, Auckland Council, technical report, TR2020/021.

Figure 2: Areas susceptible to Coastal Instability and Erosion (Auckland Council).

The existing properties are currently outside the areas identified by the Auckland Council as potentially vulnerable to coastal inundation. However, the proposed development lowers the ground levels across the sites, and therefore this report also includes brief assessment of coastal inundation hazard.

Physical Setting

The site is adjacent to Pakuranga Creek, a tributary of the upper Tamaki River estuary. The site faces southeast and is fronted by intertidal flats and a narrow tidal channel (Figure 3). The inlet is mostly inhabited by mangroves and is approximately 100 m wide.

The coastline is characterised by a steeply sloping bank cut into Tauranga Group sediments[1]. The toe of the bank is at approximately 1.0 m (AVD-46) and the crest at approximately 5.0 m (AVD, 1946). Lidar and survey data indicates that the current slope of the adjacent reserve is typically 20-26 degrees.

Figure 3: View to site of proposed Ambridge Rose Retirement Village, taken from Fremantle Place. The site of the proposed development is adjacent to the existing Ambridge Rose Manor private hospital.

Coastal Processes

Tides and Water Levels

Tides are semi-diurnal, tidal range of approximately 1.8 m (neap) and 2.9 m (spring)[3]. Stephens et al. (2013)[4] defined a recent mean sea level of +0.15 m (rel. to AVD-46) based on analysis of data from 2006-2011. The Mean High-Water Spring (MHWS) and Mean Low Water Spring (MLWS) levels are estimated at 1.56 m and -1.55 m respectively (AVD-46)[2].

The estuary adjacent to the site drains to leave a narrow channel. Elevation data[5] indicates that the intertidal flats immediately adjacent to the site have a very low gradient and extend for 40-50 m at a typical elevation of approximately 0.8-0.9 m (AVD-46) and therefore only covered at highest stages of the tide. At approximately 1.0 m (AVD), the toe of the bank is currently exposed to wetting and drying and coastal processes over the highest stages of the tide.

Wave Climate

The site of the proposed development on an arm of the Pakuranga Creek tidal inlet, a tributary of the Tamaki River estuary. The inlet is approximately 100 m wide and fully drains at low tide. At high tide, water depths are shallow (<1 m). Wave energy at the shore is therefore expected to be very low, and wave action would be limited to the highest stages of the tide and even then, dissipated by mangroves. There are two breaks in the mangrove coverage seaward of the proposed buildings which appear to the result of mangrove clearance in the past (visible cut stumps). Numerous mangrove seedlings are present

[3] LINZ NZ Tide Tables
[4] Stephens, S., Wadhwa, S. Gorman, R., Goodhue, N., Pritchard, M., Ovenden, R. and Reeve, G. 2013: Coastal inundation by storm-tides and waves in the Auckland region. Prepared for Auckland Council. NIWA Client Report No: HAM2013-059. September 2013. 206p.
[5] Auckland South LiDAR 1m DEM (2016-2017). https://data.linz.govt.nz/layer/104318-auckland-south-lidar-1m-dem-2016-2017/. LICENSE: Creative Commons Attribution 4.0 International.

in these areas, indicating vegetative cover is likely to reestablish in time. Wave activity is not likely to be a significant contributor to coastal inundation or erosion processes under current conditions.

Sea Level Rise

Coastal inundation and erosion hazard is likely to be exacerbated over time by projected sea level rise. National climate change guidance[6] defines five updated "medium confidence" scenarios for sea level rise projections, for use in coastal hazard management in New Zealand.

- SSP1-2.6 M
- SSP2-4.5 M
- SSP3-7.0 M
- SSP5-8.5 M
- SSP5-8.5 H+ (83rd percentile, or top of shaded "likely range")

Future sea level rise under these scenarios is illustrated in Figure 5. Sea level rise values in Figure 4 apply to a 1995-2014 sea level baseline, which is defined in MfE (2024) as -0.20 m (NZVD-2016)[7].

Land subsidence can increase the rate of sea level rise relative to land. The NZSeaRise Programme[8] provides specific sea-level rise projections around New Zealand, including the potential influence of vertical land movement. NZ Searise data suggests potential land subsidence at the site of 1.7 mm/yr[9], with a recognised uncertainty of +/- 1.8 mm/yr. The coastal inundation assessment below includes an allowance for this potential vertical land movement.

MfE (2024) provides recommendations for the application of sea level rise values and timeframes for a range of activity types for interim decision making in the absence of an adaptive planning strategy [6, Table 8]:

- Planning Category A: Coastal subdivision, greenfield developments and major new infrastructure: SSP5-8.5H+ (p83) to 2130 (>100 years).
- Planning Category B: Changes in land use and redevelopment (intensification and upzoning): SSP5-8.5H+ (p83) to 2130 (>100 years).
- Planning Category C: Land-use planning controls for existing coastal uses and assets (building additions): SSP5-8.5M (p50) to 2130 (>100 years).
- Planning Category D: Non-habitable, short-lived assets with a functional need to be at the coast, which are either low consequences or readily adaptable (including services): SSP5-8.5 M to 2075 (>50 years).

The proposed Ambridge Rose Retirement Village development is consistent with an activity type between Category B and Category C. Three scenarios are given in Table 1 with timeframes and sea level rise projections to reflect this national guidance and the likely lifespan of the proposed development.

[6] Ministry for the Environment, 2024. Coastal hazards and climate change guidance. Wellington: Ministry for the Environment.
[7] MfE (2024), Appendix D, Table D.1.
[8] https://searise.takiwa.co/map. Site 1284.

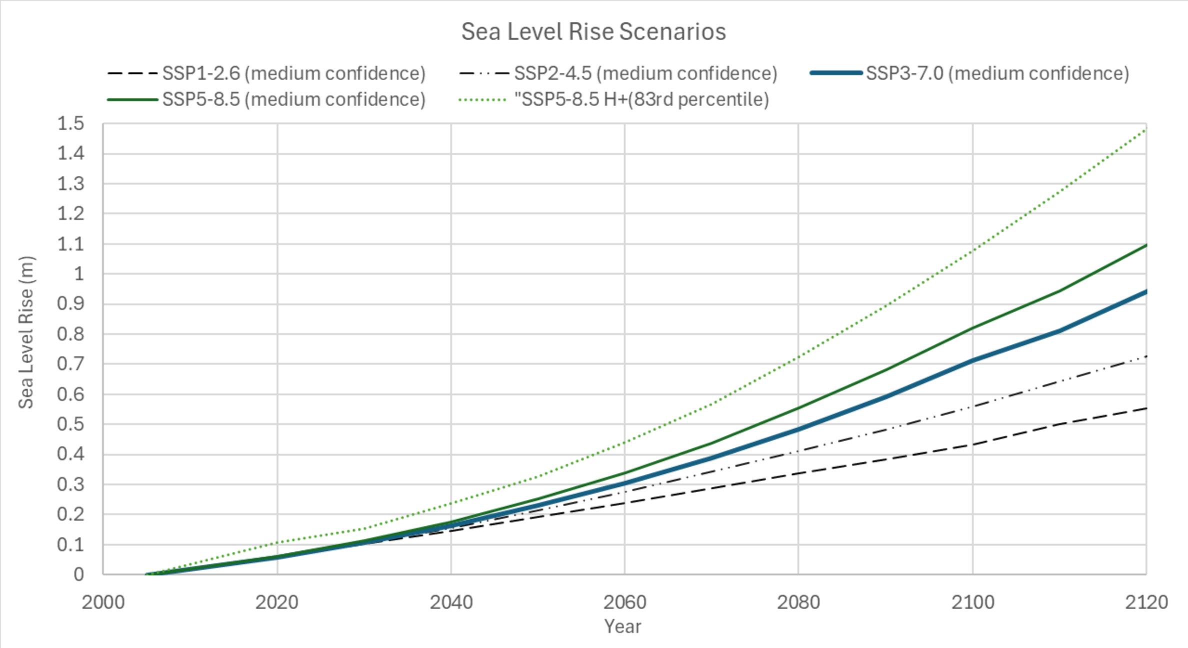

Figure 4: Sea level rise scenarios (www.searise.co.nz, site 1284).

Table 1: Future mean sea level projections for at the site for of 50-, 80- and >100-year timeframe under three sea level rise scenarios. Sea level figures are relatively to New Zealand Vertical Datum (2016) (NZVD).

	Mean Sea Level (SSP2-4.5M)	Mean Sea Level (SSP5-8.5M)	Mean Sea Level (SSP5-8.5H+) + VLM
2025	-0.12 m	-0.11 m	-0.03 m
2075	0.18 m	0.30 m	0.57 m
2105	0.40 m	0.68 m	1.15 m
2130	0.61m	1.05 m	1.71 m

Coastal Inundation Hazard

Coastal storm tide levels have been provided for Auckland's east coast estuaries by NIWA (2016)[10], including a data point at Pakuranga Creek. The 1% AEP maximum storm tide elevation is 2.33 m (MSL). Table 2 provides 1% AEP storm tide levels over the future mean sea level scenarios presented in Table 1.

Table 2: Storm tide levels at Pakuranga Creek, including future sea level rise and vertical land movement. Figures given relative to New Zealand Vertical Datum 2016.

	Storm Tide (SSP2-4.5M)	1% AEP Storm Tide (SSP5-8.5M) + VLM	1% AEP Storm Tide (SSP5-8.5+ plus VLM)
2025	2.21 m	2.26 m	2.30 m
2075	2.51 m	2.76 m	2.90 m
2105	2.73 m	3.20 m	3.48 m
2130	2.94 m	3.61 m	4.04 m

[10] Stephens, S., Wadhwa, S and Tuckey, B (2016). Coastal inundation by storm-tides and waves in the Auckland region. Prepared by the National Institute for Water and Atmospheric Research, NIWA and DHI Ltd for Auckland Council. Auckland Council technical report, TR2016/017

With a finished floor level of 5.10 m AVD-46 (4.82 m NZVD), the ground floor of the development is sufficiently elevated to be above the level of a 1% AEP event under all scenarios to 2130, including a 0.5 m freeboard. The ground elevation (4.8-5.0 m AVD, ~4.5-4.7 m NZVD) is also above storm tide level. As noted above, wave effects are expected to be minor at this site due to its sheltered location and the presence of well-established mangroves on the adjacent mudflats. The basement of Block A will be above MHWS level but below the level of storm tides during extreme events. In the future, the potential will exist for flooding should a pathway exist for water to reach the basement.

Coastal Erosion Hazard

The site is fronted by a soft, low (~4 m high) cliff formed from alluvial sediments. Cliffs, or “consolidated” shorelines erode through a one-way process that typically includes two components:

- Toe erosion: gradual retreat caused by weathering, marine and bio-erosion.
- Slope instability: in the case of a soft cliff such as in this case, episodic failure to a stable slope.

If toe erosion is stopped either due to natural processes, or by protection structures, slope adjustment will continue to occur until a stable state is reached. Figure 5 provides an illustration of the key components of cliff erosion. Coastal erosion hazard has been assessed here based on consideration of the methodology and data used to generate the existing ASCIE areas[2], analysis of historical aerial photography and a field inspection.

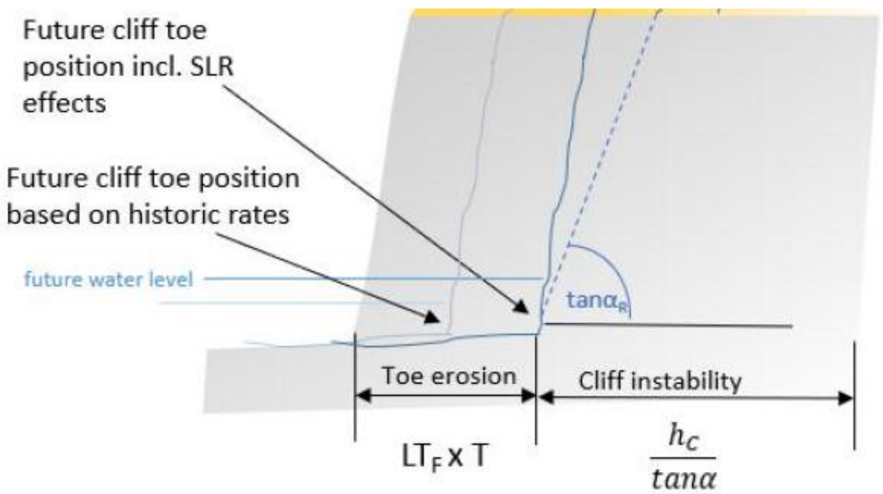

Figure 5: Key components of cliff erosion (adapted from Roberts et al. 2020[2]).

The ASCIE at the site[2] is calculated on a long-term erosion rate of 0.1 m/year, or 10 m per century[11] and a stable slope angle of 34°. The long-term erosion rate is based primarily on the underlying lithology (Tauranga Group) rather than any site-specific data about coastal erosion rates. The ASCIE scenarios present different timeframes and sea level rise scenarios.

[11] Reinen Hamill, R., Hegan, B., Shand, T. (2006): Regional Assessment of Areas Susceptible to Coastal Erosion. Prepared by Tonkin & Taylor Ltd for Auckland Regional Council. Auckland Regional Council Technical Report 2009/009.

Site Visit

The toe of the existing bank was inspected at low tide along the length of 147-153 Edgewater Drive on two occasions (3 November 2022 & 27 March 2025). The bank is heavily vegetated, and the adjacent intertidal flats are largely covered with mangroves. The intertidal flat and mangrove forest extends to the toe of the bank along most of the coastline. The high tide mark is generally 0.2-0.5 m above the toe of the slope. There was no measurable change in the horizontal location of the bank toe between the 2022 and 2025 site visit, though there were indications of localised bed lowering in areas clear of mangroves. Observations support the conclusion that any erosion at the site is very slow.

There are several existing retaining walls and toe protection structures along the frontage. Most are in a poor state of repair, and none appear to be recent, or formally engineered. All the existing seawalls appear to be informal, privately built structures, each contained within a single property. Most toe walls are made from loose or stacked rock, or concrete blocks (e.g. Figure 6), which have been placed presumedly to limit ongoing undermining of the toe of the slope. An erosion scarp approximately 0.5 m high exists along much of the foreshore where there is no protection (Figure 7). There is only a minor horizontal offset between the structures and the unprotected shoreline. The baseline applied for coastal erosion hazard mapping has been smoothed to reflect an unprotected shoreline.

Figure 6: Informal armouring structures at the toe of the slope (149 Edgewater Drive).

There is no evidence of ongoing mangrove progradation, or upper wetland vegetation at the shore, as might be expected in a highly accretionary environment. The toe of the slope extends below the high tide level and the presence of the small erosion scarp and the numerous erosion protection structures suggest that the shoreline is subject to slow erosion by coastal processes. It is very difficult to determine erosion rates in this area, except to conclude that rates are slow.

Figure 7: Vegetated bank and exposed substrate at the toe of the slope (153 Edgewater Drive).

Aerial Photo Analysis

Aerial photo survey SN3552 (1972) was orthorectified[12] to more closely examine past long-term erosion rates at the site. This provided a direct quantitative comparison of shoreline position over the last 50 years (Figure 8). Mangrove coverage was also mapped from SN3552 and Auckland urban aerial photograph (2017) to evaluate broad changes in mangrove density and cover.

The slope is heavily vegetated, with no evidence of recent significant slope failure. Available historic aerial photographs also provide no clear indication of exposed soils or fallen trees that would be expected to occur if rapid erosion was occurring at the cliff toe and driving active slope failure.

It is difficult to accurately define the toe of slope due to shading and the presence of heavy vegetation. However, the mapping exercise provided good evidence that erosion at the site has been very slow over the last 50-60 years. There was no evidence of widespread erosion beyond the error of the photography and mapping. Along some very short stretches of coast, it appears erosion of up to 2 m may have occurred. Comparison of 1959 aerial photography available through Auckland Council Geomaps with recent (2017) imagery also suggests very little change in the shoreline over the last 65 years (Figure 8).

Mangrove coverage increased most rapidly between 1959 and 1972 and has increased measurably over the last 50 years (Figure 8). More recent rectified photographs available through Auckland Council GeoMaps, LINZ data service and Google Earth indicate that there has been no measurable change in mangrove cover since the late 1990s.

[12] SKYVUW Ltd.

Figure 8: Aerial view of Pakuranga Creek (2017), illustrating position of the toe of cliff and extent of mangroves in 1972.

Coastal Erosion Hazard Area

The bank is formed from weakly cemented, erodible materials. Available evidence suggests the shoreline is experiencing ongoing slow erosion of 3-5 m per century. Erosion rates may be higher than this, but there is no evidence that erosion is as rapid as 10 m per century, as applied in the existing ASCIE[Error! Bookmark not defined.].

Future accelerated sea level rise could alter coastal processes and associated coastal erosion hazard, particularly by increasing the proportion of the tidal cycle that the shoreline is exposed to coastal processes at the toe of the bank. It is reasonable to expect that an increase in sea level will increase rates of toe erosion, in a way that is proportional to the relative increase in the rate of sea level rise.

The sea level rise component of the ASCIE is calculated based on the methods of Ashton et al. (2011)[13], which uses a generalised expression for future recession rates of cliff shorelines which applies a coefficient *m* that reflects the long-term shoreline erosion rate (LT_F) in response to increased sea level rise rates:

$$LT_F = LT_H \left(\frac{S_F}{S_H}\right)^m$$

Where LT_H is the long-term historical erosion rate, S_F is the future sea level rise rate, and S_H is the historical sea level rise rate. The ASCIE calculations at this site were based on a damped feedback

[13] Ashton, A., Walkden, M., Dickson, M.E. (2011): Equilibrium responses of cliffed coasts to changes in the rate of sea level rise. Marine Geology. 284 (s1-4) L 217-229.

system and *m*=0.3 for low wave energy environments. This approach has been applied here to consider likely future erosion rates over the lifespan of the proposed development.

To reflect the uncertainty in defining long term erosion and the effect of future sea level rise, this report presents a range of scenarios for future shoreline change that reflect four scenarios:

- 2075 SSP2-4.5M: moderate sea level rise rate, past long term average erosion rate of 0.03 m/yr. This coastal erosion hazard area is likely to be affected by coastal erosion over the lifespan of the proposed buildings (50-year timeframe).
- 2075 SSP5-8.5M: long-term erosion rate of 0.05 m/yr and more precautionary sea level rise rate to reflect national guidance. Erosion beyond this zone is unlikely over the 50-year timeframe.
- 2105 SSP5-8.5M: long-term erosion rate of 0.05 m/yr over a longer timeframe to reflect a possible maximum building lifespan.
- 2130 SSP5-8.5H+: this scenario is a long term (100+ year) consideration of the possible erosion hazard associated with a precautionary sea level rise scenario and maximum (unlikely) underlying erosion rate (0.01 m/yr).

The calculations are based on an historical sea level rise rate of 3.0 mm/yr[14] and future sea level rise rates reflect those presented in the NZ Sea Rise Project[15] (Figure 4). The additional horizontal distance required to provide for slope stability is based on a toe elevation of 1.0 m and a land elevation of 4.8 m (AVD-46). These scenarios illustrate a range of possible futures to evaluate the potential for hazard to affect the proposed development over the likely building lifespan and beyond.

The 2130 SSP5-8.5M5H+ scenario presented here represents coastal hazard risk at a timeframe that is relevant to land use planning but exceeds the expected lifespan of the proposed development. This scenario represents the possible (but unlikely) underlying erosion rate of 10 m per century[16], further accelerated by a high sea level rise trajectory. The coastal hazard areas are illustrated in Figure 9.

Table 3: Coastal erosion hazard distances for a range of possible scenarios.

	Hazard Area (2075 SSP2-4.5)	Hazard Area (2075 SSP5-8.5)	Hazard Area (2105 SSP5-8.5)	Hazard Area (2130 SSP5-8.5H+)
LT	1.6 m	3.4 m	5.7 m	16.2 m
Slope	5.6 m	7.8 m	7.8 m	9.4 m
TOTAL:	7.2 m	11.2 m	13.5 m	25.6 m

[14] https://www.stats.govt.nz/indicators/coastal-sea-level-rise/
[15] https://searise.takiwa.co/map/, site 1284
[16] As adopted in ASCIE Roberts et al. 2020.

Figure 9: Coastal erosion hazard estimates, illustrated in relation to the footprint of the proposed buildings.

Coastal Hazard Risk

Coastal hazard risk is a product of likelihood and consequence of a hazard affecting the property or assets. The proposed development represents a significant increase in the intensity of use of the four properties on Edgewater Drive, which are currently each occupied by a single residential dwelling. The consequence of a coastal hazard has therefore increased in terms of the scale and value of the buildings and infrastructure, and the number of people affected.

Coastal Inundation Risk

With a finished ground level of 4.8-5.0 m (AVD-46), the properties are well above the level of a 1% AEP storm tide event, including allowance for freeboard and projected sea level rise. The basement of Block A will be above MHWS level but below the level of storm tides during extreme events. The potential will exist for flooding in the future if a pathway exists for water to reach the basement. This report assumes that the design of the basement and associated pumping system has considered these factors, including the implications of future sea level rise.

Coastal Erosion Risk

The proposed development is close to the coastal margin. Coastal erosion risk at the property is difficult to quantify accurately. Available data and field inspections indicate that some erosion is occurring on this shoreline, but rates of erosion appear to be very slow. Several scenarios were investigated due to uncertainties in determining both the underlying historical erosion rates, and the response of the shoreline to sea level rise in the future. Figure 10 and Figure 11 provide cross-sectional views of the potential coastal erosion hazard in relation to the properties and proposed buildings under different timeframes and levels of precaution.

The basement of the proposed Block A is located approximately 6 m landward of the top of the coastal slope. Future erosion and associated slope adjustment beyond a 50-year timeframe could expose the basement wall. The seaward edge of Block B is likely to be landward of coastal erosion for at least 80 years.

Figure 10: Coastal erosion hazard in relation to the ground floor and basement of Block A.

Figure 11: Coastal erosion hazard in relation to the ground floor of Block B.

Summary

The proposed finished ground level at the Ambridge Rose development is above the level that is likely to be vulnerable to coastal inundation, including the effects of sea level rise and water level fluctuations.

The Auckand Council ASCIE (Areas Susceptible to Coastal Inundation and Erosion) indicate that the proposed development is potentially vulnerable to coastal erosion and instability. These areas were calculated based on a long-term erosion rate of 0.1 m/yr, or 10 m per century, accelerating due to future sea level rise. This is a generalised rate applied to sheltered environments in Tauranga sediments. Local features and the presence of numerous informal coastal protection structures indicate slow erosion is occurring, but the aerial photographic record and field observations suggest erosion is occurring at a slower rate than 10 m per century. It is very difficult to accurately quantify these erosion rates, but in this case, they have been estimated at 3-5 m/century.

The short-term coastal erosion risk to the property and the proposed development is very low. There is likely to be very slow ongoing erosion, which over time may lead to slope instability. The timing and significance of coastal erosion hazard will depend on the rate of future sea level rise and the response of the local environment to rising sea levels. The long-term effects on the exposure and erosion of the toe are likely to be relatively minor if sedimentation rates in the estuary keep pace with sea level rise. If sea level rise exceeds sedimentation rates, exposure of the coastline to active coastal processes will increase and the rate of toe erosion may also increase.

A range of scenarios have been presented here to address different timeframes and sea level rise rates and the uncertainty in defining coastal erosion hazard risk in the long term.

The coastal erosion hazard risk to the proposed development is summarised as:

- The basement of Block A is unlikely to be exposed by coastal erosion for at least 50 years. It is possible that erosion could reach the basement over longer timeframes (e.g. >50 years and >0.6 m of sea level rise).
- Block B is unlikely to be affected by coastal erosion in the next 80 years.

While the scenarios cover a range of likely and possible sea level rise trajectories, they are based on assumptions and estimates of the underlying erosion rates and likely response of the shoreline to increases in sea level based on limited site-specific information. It is still possible that future outcomes will occur outside of these estimates.

Recommendations

There is no immediate threat to the proposed development from coastal erosion. Over the lifespan of the proposed buildings, the coastal erosion hazard risk likely to remain low, but under a particularly rapid sea level rise trajectory, a stronger shoreline response could result in shoreline erosion that threatens the development. The hazard is related to slope instability due to slow toe erosion in a low energy environment rather than rapid shoreline change.

The coastal erosion risk relates mostly to the implications of the exposure of the basement wall of Block A, and whether mitigation of this hazard is practicable or necessary. Coastal hazard risk is otherwise limited to landscaped areas and the access road seaward of Block B. Some form of monitoring and management plan may be advisable to consider potential actions in response to sea level rise and ongoing erosion.

Given the long-term nature of the potential hazard, and the associated uncertainties, the coastal hazard could be managed with a simple plan for monitoring and mitigation:

- Regular (5-yearly) monitoring and brief report to include:
    - coastal conditions (toe erosion, processes and vegetation, sea level)
    - observations of slope instability
    - reporting of any action required if deemed risk within ten years.
- Adaptation of access roads, hard landscaping features if necessary
- Construction of a retaining wall to protect buildings or critical infrastructure if necessary.